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# BUREAU OF MINES MINERALS YEARBOOK

# Gold

UNITED STATES DEPARTMENT OF THE INTERIOR

**The statistical data in this volume represents the most comprehensive, verified, domestic and international coverage for 1987 at the time the volume went to press. More recent information can be found in the monthly Gold and Silver Mineral Industry Surveys obtainable from Publications Distribution, Bureau of Mines, Box 18070, Cochrans Mill Road, Pittsburgh, PA 15236.**

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**UNITED STATES DEPARTMENT OF THE INTERIOR • Donald Paul Hodel, Secretary**

**BUREAU OF MINES • T S Ary, Director**

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# Gold

By John M. Lucas[1]

World gold mine production reached its highest recorded level in 1987. U.S. mine production also reached its highest level, registering a strong 33% increase over 1986 production. Nevada was again the principal gold-producing State, having increased pro-

**Table 1.—Salient gold statistics**

| | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| **United States:** | | | | | |
| Mine production, thousand troy ounces | 2,602 | 2,865 | 2,427 | r3,739 | 4,966 |
| Value, thousands | $649,871 | $751,823 | $771,082 | r$1,376,855 | $2,224,697 |
| Percentage derived from: | | | | | |
| Precious metals ores | 93 | 87 | 92 | 96 | 91 |
| Base-metal ores | 14 | 11 | 5 | 2 | 6 |
| Placers | 3 | 2 | 3 | 2 | 3 |
| Refinery production: | | | | | |
| Domestic and foreign ores, thousand troy ounces | 1,972 | 2,181 | 2,076 | r2,396 | 3,613 |
| Secondary (old scrap), do. | r1,784 | r1,769 | r1,602 | r1,345 | 2,034 |
| Exports: | | | | | |
| Refined, do. | 1,881 | 2,482 | 2,886 | r3,554 | 2,256 |
| Other, do. | 1,256 | 1,499 | 1,979 | 1,441 | 1,556 |
| Imports for consumption: | | | | | |
| Refined, do. | 3,589 | 6,032 | 6,361 | 13,800 | 2,425 |
| Other, do. | 984 | 1,837 | 1,965 | 1,949 | 1,439 |
| Gold contained in imported coins[2], do. | 1,948 | 2,749 | 2,864 | 1,191 | 2,064 |
| Net deliveries from foreign stocks in Federal Reserve Bank, do. | -229 | 381 | 482 | 4,692 | 2,059 |
| Stocks, Dec. 31: | | | | | |
| Industry[3], do. | r611 | r732 | r596 | r805 | 732 |
| Futures exchange, do. | 2,530 | 2,359 | r2,119 | r2,869 | r2,825 |
| Department of the Treasury: | | | | | |
| American Eagle gold coin sales, do. | -- | -- | -- | r[4]2,212 | 1,491 |
| Bicentennial of the U.S. Constitution coin sales, do. | -- | -- | -- | -- | [5]800 |
| Gold medallion sales[6], do. | 434 | 419 | 48 | (7) | -- |
| Olympic gold coin sales, do. | -- | [8]156 | 24 | (7) | -- |
| Statue of Liberty gold coin sales, do. | -- | -- | [9]121 | [10] | -- |
| Consumption in industry and the arts, do. | r3,075 | r3,140 | r3,097 | r3,126 | 3,226 |
| Price:[11] Average per troy ounce | $424.00 | $360.06 | $317.46 | $368.24 | $447.36 |
| Employment[12] | 6,300 | 6,900 | 6,300 | r5,300 | 11,300 |
| **World:** | | | | | |
| Mine production, thousand troy ounces | r45,163 | r46,827 | 49,194 | r51,629 | r52,451 |
| Official reserves[13], million troy ounces | r1,143.5 | r1,142.5 | r1,145.2 | r1,143.5 | 1,143.9 |

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Calculated by the Gold Institute from reports by the Bureau of the Census.
[2]Unfabricated refined gold held by refiners, fabricators, dealers, and U.S. Department of Defense.
[3]Commodity Exchange Inc. only. Stocks held by other exchanges estimated to be less than 2% of totals shown.
[4]Sales program began Oct. 20, 1986.
[5]Sales program began July 1, 1987.
[6]Sales program began July 15, 1980.
[7]No sales. No action was taken on the reauthorization bill by the 99th Congress.
[8]Includes coins sold in 1982 and 1983 for delivery in 1984.
[9]Authorization sales program fulfilled in 1985.
[10]Sales completed by yearend 1985 for delivery in early 1986.
[11]Engelhard Industries quotation.
[12]Mine Safety and Health Administration.
[13]Held by market economy country central banks and governments and international monetary organizations.
Source: International Monetary Fund.

duction more than tenfold since 1979. The overall demand for gold for use in fabricated products in the market economy countries declined from the level of 1986 partly because of a drop in coinage in Japan. Gold continued to be used in high-technology applications, especially in the aerospace and electronics industries.

Despite an apparent excess of supply over identifiable demand, the firmness of the price during the year suggested that the surplus had been easily absorbed by investors, especially in Europe and North America.

**Table 2.—Volume of U.S. gold futures trading**

(Million troy ounces)

| Exchange | Location | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| Chicago Board of Trade | Chicago | 10.15 | 9.73 | 5.42 | 4.00 | 8.074 |
| Commodity Exchange Inc | New York | 1,038.28 | 911.55 | 788.40 | 842.96 | 1,029.31 |
| International Monetary Market[1] | Chicago | 99.40 | 89 | (2) | (2) | 28.16 |
| MidAmerica Commodity Exchange | do | 11.59 | 2.02 | 1.04 | .70 | .65 |
| Total | | 1,159.42 | 924.18 | 794.86 | 847.66 | 1,064.19 |

[1]A division of the Chicago Mercantile Exchange.
[2]Less than 1,000 ounces traded. Trading ceased July 10, 1985, and resumed June 16, 1987.

**Domestic Data Coverage.**—Domestic mine production data for gold are developed by the Bureau of Mines from two separate, voluntary surveys of U.S. operations. Typical of these surveys is the lode-mine production survey of copper, gold, lead, silver, and zinc mines. Of the 555 lode gold operations to which a survey request was sent, 69% responded, representing 95% of the total lode-mine production of gold shown in tables 6 and 7. Production for the nonrespondents was estimated using reported prior year production levels, adjusted by trends in employment and other guidelines such as company annual reports, the news media, and State agency reports.

**Legislation and Government Programs.**—As required by legislation enacted in 1986, up to 1 million $5 gold coins, each containing 0.24 ounce[3] of gold, were to be minted to commemorate the Bicentennial of the U.S. Constitution. The first of these coins was struck on July 1.

Legislation to mint 1 million gold coins, each containing 0.24 ounce of gold, and 10 million silver coins, each containing 0.77 ounce of silver, commemorating the 1988 Olympic games, was approved as Public Law 100-141. Both coins were to be legal tender. The coin prices were to be established by the U.S. Department of the Treasury. They were to include a surcharge of $35 on each gold coin and $7 on each silver coin, to be used to support the training of present and future U.S. athletes in the 1988 Olympic games. A sunset provision was to terminate minting activity on June 30, 1989.

## DOMESTIC PRODUCTION

Numerous properties were brought into production and decisions to expand production capacity were implemented at a number of existing mines. A large percentage of the new mines beginning or planned were to employ heap-leaching and recovery techniques pioneered by the Bureau of Mines.

Of the 4.9 million ounces of gold produced in the Nation, 76% was attributable to the 25 leading producers. The average recoverable gold content of precious metals ores processed from lode mines was 0.05 ounce per short ton, while placer gravels yielded an average of 0.03 ounce per cubic yard washed.

The revisions in domestic refinery production data for 1983-87 shown in table 10 reflect the inclusion of newly reported data and account more accurately for the contribution of several existing refineries, plus the addition of some previously unreported metal of both primary and secondary origin.

**Table 3.—Mine production of gold in the United States, by State**

(Troy ounces)

| State | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| Alaska[1] | 39,523 | 19,433 | 44,723 | 48,271 | 86,548 |
| Arizona | 61,991 | 54,997 | 82,069 | W | 96,240 |
| California | 38,443 | 85,856 | 187,813 | 425,617 | 602,616 |
| Colorado | 62,063 | 60,019 | 43,991 | 129,347 | 178,796 |
| Idaho | W | W | 44,906 | 70,449 | 97,773 |
| Michigan | | | W | W | W |
| Montana | 161,436 | 181,196 | 160,262 | W | 234,365 |
| Nevada | 980,457 | 1,020,546 | 1,276,114 | [2]1,698,999 | 2,879,479 |
| New Mexico | W | W | 45,945 | 39,856 | W |
| North Carolina | | | | 12 | W |
| Oregon | 822 | W | W | W | W |
| South Carolina | | | W | W | W |
| South Dakota | 309,784 | 310,527 | 356,103 | W | W |
| Utah | 226,459 | W | 135,489 | W | W |
| Washington | W | W | W | W | W |
| Total | 2,002,526 | 2,054,615 | 2,427,232 | [2]2,739,015 | 4,346,392 |

[1]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[2]These figures, reported to the Bureau of Mines, probably understate production. Data collected by the State indicate production to have been as follows, in troy ounces: 1983—169,000; 1984—175,000; 1985—190,000; 1986—160,000; and 1987—230,000.

**Alaska.**—Despite continuing conflict between environmentalists and Alaska's small- and medium-size placer miners during 1987, placer mine production, which accounted for 97% of the State's gold production, increased for the fourth consecutive year. The quantity of gold produced in Alaska and reported to the Bureau of Mines increased by nearly 80% over that reported in 1986. However, an informal annual survey of Alaska's gold producers, begun several years ago by the Alaska State Division of Geological and Geophysical Surveys (DGGS), again suggested that a much larger quantity, nearly 230,000 ounces, had actually been produced. This figure compares with similarly derived figures for 1982-86 of 174,900, 169,000, 175,000, 190,000, and 160,000 ounces, respectively. The value of 1987 production was estimated by the State at nearly $105 million, up 71% over the 1986 estimate. The DGGS, in its annual review of mining activity in the State, cosponsored by the Alaska Division of Business Development, noted that the production increase was the result of increased production from a few major operations, offsetting a reduction in the number of small placer operations.[3] Expenditures for exploration, development, and production, a large portion of which was for precious metals, together increased 37%. Direct employment increased by 349 jobs to nearly 3,000. There were 202 mechanized placer mines and 3 lode mines reportedly in operation in Alaska during 1987. There was a significant decrease in the number of small placer mines from 1985 through 1987. Many small family-operated mines were squeezed out of business, reportedly because of regulatory and legal problems.

According to the State review, the number of small placer mines in Alaska declined by 27% during 1987. The most severe constraint on small miners in 1987 was a court injunction that prohibited the Bureau of Land Management (BLM) from allowing placer mines to disturb more than 5 acres of land on four major State drainages until BLM completes cumulative environmental impact statements and other assessments on the land in question. The injunction was a result of a lawsuit brought by the Sierra Club against BLM. It was expected to halt some placer mining in key interior Alaska mining districts for 1 to 3 years. Also during the year, the Corps of Engineers was directed to begin developing a permit process for Alaskan placer mines starting in 1988. The Corps of Engineers is responsible for permitting activities on all wetlands, regardless of ownership.

Other difficulties facing Alaskan miners were continuing water-quality problems and a legal challenge by a coalition of environmentalists and native groups challenging the mining claim location and leasing system of Alaska. The Governor directed State agencies to develop an acceptable plan regarding water quality before the 1988 mining season to protect the rights of both placer miners and other water users.

The Valdez Creek Mine, a placer gold mine owned by Valdez Creek Mining Co. Inc., a consortium of Canadian firms, was the State's largest gold producer for the

fourth consecutive year. According to published data, the mine, off the Denali Highway near Anchorage, produced more than 32,000 ounces of gold. By modifying its open pit mining technique, and by using a winter-protected screening plant and sluice box recovery system, the company determined in 1987 that it could reliably operate throughout the winter at temperatures as low as -25° to -35° F. Near Nome, the Alaska Gold Co., 85%-owned by Sharon Steel Corp., operated its No. 5 and No. 6 floating bucketline dredges during the season, processing about 1.4 million cubic yards of gravel. This amount is nearly double the quantity processed in 1986, when only one dredge was being used. In Norton Sound, offshore Nome, Western Gold Exploration and Mining Co. Ltd. Partnership (WestGold), 50% held by Inspiration Gold Inc., completed a successful first season of offshore mining with its mining vessel, the *BIMA*, recovering 36,600 ounces of gold. Also near Nome, the Windfall Gold Mining Co. again operated its Copper Gulch open pit, stripping 270,000 cubic yards of overburden and sluicing an estimated 630,000 cubic yards of gravel.

Callahan Mining Corp., owner of 79.5% of Livengood Placers Inc., which mines properties 60 miles north of Fairbanks, reported that its contract operator recovered nearly 2,900 ounces of gold in 1987 from previously worked areas. Work during the 1987 season concentrated on higher grade ore pockets encountered in the bottom of the pit. The contractor stripped 585,000 cubic yards of overburden to prepare another area for sluicing during the 1988 season, from which 3,000 ounces of recovery was expected.

At Eater Dome near Fairbanks, the Grant gold mine of Silverado Mines Ltd. was reopened in December, following a nearly 2-year redevelopment period during which operations were converted from underground to open pit mining. Gold recovery at the mine's 250-ton-per-day mill and carbon-in-pulp recovery plant reportedly was running at about 94% by yearend. Contiguous to the Grant pit is the Ryan Lode property owned by Citigold Alaska Inc., a subsidiary of La Teko Resources Ltd. of Canada, where the owners completed their first full year of a full-scale heap-leaching test. The operation reportedly reversed the conventional heap-leaching procedures customarily used in the lower 48 States, such as Nevada, by using heap leaching to process small tonnages of high-grade ore rather than a large tonnage of low-grade ore. About 6,100 ounces of doré reportedly was recovered by La Teko in 1987, making it the State's largest lode gold producer.

The $82 million Greens Creek Mine on Admiralty Island was scheduled to begin production at the rate of 84,000 tons per year of silver-gold-lead-zinc-bearing concentrates in September 1988. In addition to 6.4 million ounces of silver, the mine was expected to yield 36,000 ounces of gold per year and employ a workforce of about 250. The mine was being developed by Amselco Minerals Inc. and its partners Hecla Mining Corp., CSX Oil and Gas Corp., and Exalas Resources Corp.

Exploration for gold continued in many areas of the State. On Chichagof Island, Golden Sitka Resources Inc. continued exploration at the Hirst-Chichagof underground mine. At the old Alaska-Juneau Mine at Juneau, once the largest gold mine in the Nation, Echo Bay Mines Ltd. continued underground exploration, reserve development, and evaluation with the possibility of beginning production in mid-1991. Echo Bay and Coeur d'Alene Mines Corp. also acquired the Kensington Mine near Berner's Bay, 50 miles north of Juneau. Plans called for an evaluation and feasibility period lasting into early 1989.

A report prepared by the Bureau of Mines described the history, characteristics, and mineral development potential of 21 lode gold deposits in or near the Chugach National Forest of Alaska. It includes findings from a recent 4-year mineral evaluation of the forest conducted by the Bureau and the U.S. Geological Survey. Of the 21 lode deposits described, 14 contain a combined identified resource of 117,750 tons averaging 0.55 ounce of gold per ton and 0.2 ounce of silver per ton.[4] In another report the Bureau estimated the remaining lode gold endowment of eight Alaskan mining districts using historic production data. To assess the remaining endowment, a computerized production data base was compiled from Bureau records. Based on a conservative extrapolation of grade-tonnage curves generated by the study, a substantial total endowment of 8.4 million ounces remained in the eight districts. The Chichagof, Fairbanks, Juneau, and Willow Creek Districts have the greatest remaining endowment.[5]

Arizona.—Higher prices for gold, especially during the last three-quarters of the year, reportedly led to a significant increase in exploration activity in the State, with gold or gold and silver listed as the objective of 29 out of 33 projects undergoing exploration during the year.

In La Paz County, Cyprus Copperstone Gold Corp. produced the first gold from its new $13.9 million Copperstone Mine in

November. Copperstone produced about 6,000 ounces of gold in 1987 and more than 60,000 ounces was expected in 1988. Surface mine life, based on currently known open pit reserves of 510,000 total contained ounces, was estimated at 6 years. Gold ore reserves were 6 million tons containing an average of 0.085 ounce of gold per ton. Drilling around and under the current open pit area revealed higher grade ore that may be obtained through underground mining.

Three properties in advanced stages of exploration and development were Ivy Mineral Inc.'s Gold Bug Mine, 30 miles northwest of Chloride in Mohave County, and Echo Bay's Congress Mine and Stan West Mining Corp.'s McCabe Mine, both in Yavapai County, southeast of Prescott. All three were expected to reach production in 1988.

**California.**—Gold production in California increased by 41%, reaching its highest level since 1942. Several new mines commenced production in 1987, capacity increases were under way at several operating properties, and several properties were in various preproduction phases ranging from ore reserve confirmation and permitting to final plant construction.

In Imperial County, east of Brawley, the Mesquite Mine of Gold Fields Mining Corp., a wholly owned subsidiary of Consolidated Gold Fields PLC of the United Kingdom, completed its first full year of production. According to Consolidated's annual report, Mesquite's production during the fiscal year, all from heap leaching, amounted to over 180,000 ounces. The necessary permits were being sought to increase ore production from 3.3 million tons per year to nearly 5 million tons annually by mining the nearby Cherokee, Rainbow, and Vista deposits.

At the McLaughlin Mine near Clearlake in northern California, one of the State's largest gold mines, production increased nearly 10% to almost 190,000 ounces at an average cash cost per ounce of $229 compared with $240 in 1986. Homestake Mining Co., one of the Nation's top gold producers, announced that design engineering studies were begun in September on a $25 million expansion program aimed at increasing the annual production rate at McLaughlin by 50,000 ounces by 1989.

On the outskirts of the town of Jamestown in Tuolumne County, Sonora Gold Corp.'s new Jamestown Mine completed its first full year of production. The new open pit, opened on the site of the old Harvard Mine, was designed to yield about 130,000 ounces of gold and 59,000 ounces of silver per year. The mine reportedly contains sufficient reserves to last 14 years at a gold price threshold of $300 per ounce. The mine's new $85 million flotation mill was officially opened in March. To the south in Mariposa County, Goldenbell Resources Inc. continued work on its Pine Tree gold property, a planned 130,000-ounce-per-year open pit scheduled to begin production in late 1988 or early 1989. Sonora and Goldenbell are members of the ABM Mining Group Inc. of Vancouver, British Columbia, Canada.

Other gold mines beginning or resuming production in California during 1987 included the Kramer Hills, Standard Hill, Sixteen-to-One, Goldstripe, Mount Gains, Yellow Aster, and Morning Star. At the Kramer Hills property on the edge of Edwards Air Force Base in San Bernardino County, Beaver Resources Inc. reportedly began full-scale open pit mining in early 1987. Heap leaching was being used for recovery, and plans were formulated to expand the capacity of the property from about 12,000 ounces to 48,000 ounces per year. The company reportedly concluded an agreement with Noranda Exploration Inc. and Hemlo Gold Mines Inc. to explore and develop an adjoining property.

Near the town of Mojave in Kern County, Billiton Minerals USA Inc., a wholly owned subsidiary of Shell Mining Co., began mining at the Standard Hill gold mine in August. Royal Gold Inc. of Denver, CO, began production at two mines in 1987. In July, Royal and its partner, Lucky Chance Mining Co., poured the first gold from the old Sixteen-to-One Mine near Alleghany in Sierra County. This underground mine has been a prolific gold producer periodically since 1896 with estimated total production exceeding 1 million ounces. The partners expected to recover about 14,000 ounces of gold annually from high- and low-grade milling ores as well as small quantities of hand-sorted specimen gold and "jewelry rock" containing visible gold. Royal's second mine to resume work was its recently acquired Goldstripe property in Plumas County near Lake Almanor. Seasonal mining, begun in September at a rate of 1,600 tons per day, was by open pit. Gold was recovered using agglomeration heap leaching. At full capacity, annual production of Goldstripe was expected to be about 20,000 ounces. In early 1987, Royal sold its interest in the Colosseum Mine in San Bernardino County to Colosseum California Inc. and Dalhold Investments Pty. Ltd. of Perth, Western Australia. In Mariposa County, Mount Gains Resources Inc., using heap leaching, reportedly produced about

3,000 ounces of gold from tailings and ore mined from the underground workings at the old Mount Grins Mine. Near yearend, Terramar Resources Corp. of Vancouver, Canada, was negotiating with the owners to gain control of the property. Glamis Gold Inc. reported that the first gold was poured at its Yellow Aster Mine near Randsburg in Kern County from production on the Lamont zone. Production on the Descarga dumps was ready to begin at yearend. The Lamont and Descarga were to feed the system for about 2 years, during which time the main Yellow Aster ore body was to be permitted and phased into production. Glamis' other California Mine, the Picacho in eastern Imperial County, yielded 24,000 ounces during the fiscal year ending October 31. In San Bernardino County, Vanderbilt Gold Corp. completed its first year of mining at its Morning Star open pit and heap-leaching facility.

Properties under development and nearing production during the year included the Snow Caps open pit and heap-leaching operation in Inyo County, belonging to Sunshine Mining Co. and First Sierra Assets Inc.; and the Bagdad-Chase Mine of Bentley Resources Ltd. in San Bernardino County. In the same county, Viceroy Resources Corp. moved toward an early 1988 startup at its Castle Mountain property in the Hart Mountains; Alpine County's Zaca Mine, owned by Pegasus Gold Inc. and California Gold Mines Ltd., was expected to begin production within 2 years.

Colorado.—In Rio Grande County, the Summitville Mine, an open pit heap-leaching operation, completed its first full year of production. Galactic Resources Ltd. of Vancouver, Canada, reported that gold produced through the third quarter of 1987 amounted to nearly 60,000 ounces. At a recovery rate of greater than 10,000 ounces per month toward yearend, gold produced by the end of the leaching season in November amounted to over 88,000 ounces, thus making Summitville by far the State's largest gold producer.

The State's second largest mine, the Sunnyside gold mine in San Juan County, also completed its first full year of production under its new owner, Echo Bay, which had extensively refurbished the mine. Sunnyside, at Silverton, operated by Echo Bay's wholly owned subsidiary, Sunnyside Gold Corp., produced over 47,000 ounces of gold and over 446,000 ounces of silver in 1987. In an effort to reduce production costs, the owners reportedly devoted 1987 to modernizing equipment, increasing productivity, and developing more underground areas.

Golden Cycle Gold Corp. of Colorado Springs reported that, with its partner, Texasgulf Minerals and Metals Inc., working together under a joint venture named Cripple Creek and Victor Gold Mining Co., more than 28,000 ounces of gold was recovered from a continuing dump-leaching operation known as the Mine Dump Project. Heap leaching has been employed in the project since 1984 to recover gold from mine dumps in the Cripple Creek area of Teller County. Texasgulf, a subsidiary of Société National Elf Aquitaine, a French corporation, was manager of the partnership. The company continued exploration of its Minerex area in Teller County, and a decision was made to move ahead with the construction of a new open pit and heap-leaching project, also in Teller County, known as the Portland area. By yearend 1987, work on the Portland area included the partial construction of a leach pad and the mining and stockpiling of 120,000 tons of ore bearing an average grade of 0.8 ounce of gold per ton. An estimated 16,100 ounces was to be recovered from the Portland area in 1988. The partners also constructed a new 150-ton-per-day mill designed to incorporate portions of their existing Carlton mill while providing capacity to handle a wider range of ore grades. Work was also under way to develop another Teller County property named the Proper Stopes. Included on the property were the old Chicago Tunnel and Poverty Gulch areas. Underground mining was expected to yield nearly 4,000 ounces during 1988. Another old gold-producing mine, the Camp Bird Mine, was being reopened near yearend by Chipeta Mining Corp., and several partners collectively known as the Camp Bird Venture. Chipeta, wholly owned by Western Mining Corp. Holdings Ltd. of Australia, owns 76% of the venture. The partners expect to recover about 10,000 ounces of gold during the 1987-88 fiscal year.

In Gilpin County near Idaho Springs, Franklin Consolidated Mining Co. Inc. in a joint venture with Consolidated Knobby Lake Mines Ltd. of Vancouver, Canada, reportedly reopened the old underground Franklin Mine. Toward yearend, mining and milling were reportedly progressing at a rate of nearly 100 tons of ore per day. In Gunnison County, Great West Gold and Silver Inc. reportedly began heap leaching at its Vulcan (Good Hope) property.

The Leadville Corp. began construction of a production facility at the Diamond shaft site on its Resurrection Mine near Leadville in Lake County. When completed in mid-1988, the property was expected to produce about 30,000 ounces of gold per year. In the

Alma mining district of Park County, Cobb Resources Corp. negotiated a joint venture agreement with Boulder Gold Inc. of Australia for the purpose of returning the old London gold mine to productive status. At yearend, surface and underground development and engineering studies were under way and the construction of a new 500-ton-per-day mill was being considered. Battle Mountain Gold Co. (BMG) acquired the San Luis project in Costilla County. Subsequent drilling and examination of the property confirmed estimated proven and probable minable reserves of about 390,000 ounces of gold. BMG planned to bring the property into production in 1989 at an annual rate of 40,000 ounces of gold. Exploration and preproduction development continued on a number of other properties throughout Colorado.

Idaho.—Data contained in a review prepared by the Idaho Geological Survey[6] indicated that the value of gold production in that State rose by nearly 74% over that of 1986 and the number of exploration projects, mostly for gold, increased to 61 in 1987 from 38 in 1986, with epithermal-type disseminated gold deposits reported to be the principal targets.

During the year, a task force composed of industry, government, and conservation groups drafted the first modern regulations in the United States governing the use of cyanide in mining. The rules were designed to safeguard against accidents involving the use of cyanide, especially in heap leaching. State approval of the proposed regulations was pending at yearend.

The State's largest gold mine, the Pioneer Metals Corp.-TRV Minerals Corp.-Mining Finance Corp.'s Stibnite-West End Mine, a seasonal open pit and heap-leaching operation south of Yellow Pine in Valley County, produced over 30,000 ounces of gold during the year. Hecla signed an agreement with Pioneer for the latter to process oxidized gold-bearing tailings material from the old Yellow Pine tungsten and antimony mine near Stibnite. Pioneer was to begin processing the material in 1988. During the term of the agreement, 1988-91, about 25,000 ounces of gold was expected to be credited to Hecla's account.

Coeur d'Alene Mines completed its first full year of production at its new Thunder Mountain Mine in eastern Valley County. This open pit heap-leaching facility, which operated from May through October, yielded more than 27,000 ounces of gold during 1987. The mine was selected by the Pacific Northwest Pollution Control Association as the Idaho recipient of the association's 1987 State Industrial Pollution Control Award.

Nerco Inc.'s Delamar silver and gold mine in Owyhee County produced 30,200 ounces of gold and 1.7 million ounces of silver in 1987. A new heap-leaching facility to be used in tandem with the existing agitation-leach recovery system was added in 1987. The addition was designed to recover an additional 65,000 ounces of gold and 1.4 million ounces of silver from lower grade ore over the next 7 years.

In the Yankee Fork mining district, U.S. Antimony Corp. (USAC) continued to operate its 300-ton-per-day flotation and cyanide leach mill at Preacher's Cove near Yankee Fork on the Salmon River. Feed for the mill is derived from USAC's properties on Estes Mountain and near Custer, plus shipments of ore from small miners delivered for custom milling. Exploration and geological studies by USAC at its Custer pit reportedly suggested the presence of a substantial ore body. Open pit mining on the company's Yellow Jacket property southwest of Salmon began in July. Detailed drilling at the Valley Creek property near Stanley was under way to test the possibility of an open pit mine. Also near Stanley, Sunbeam Mining Co., a subsidiary of Geodome Resources Ltd., was in the permitting stage toward opening its open pit Sunbeam (Jordan Creek) Mine and vat-leaching mill. Sunbeam anticipated recovery of 40,000 to 50,000 ounces per year when production begins in 1988.

Near the town of Bridge in Cassia County, Noranda Inc. submitted a mine development proposal to the U.S. Forest Service outlining its plan to develop a small heap-leaching operation in the Black Pine Mountains. If approved, the Black Pine Mine would begin production in 1988, mining from three small open pits. Other properties under development by other companies include the Robinson Dyke and Buffalo Gulch Mines, both near Elk City, and the Atlanta gold mine at Atlanta Hill. A dozen or so placer mines were also operated during the year. The largest, situated near Lucille, was by A & T Mining.

Montana.—At least three gold mines commenced production in 1987 while several others had been proposed or neared a projected 1988 startup. Fewer new applications for exploration were filed in 1987, according to a State report summarizing mining and mineral developments in Montana during 1987,[7] but applications for renewals increased while drilling activity and performance also increased. Exploration apparently shifted during the year from basic prospecting to work aimed at proving the

worth of earlier discoveries.

Pegasus acquired a 100% working interest in the developing Montana Tunnels property in Jefferson County from its partner in the venture, U.S. Minerals Exploration Co. Pegasus reported that 1987 production at the open pit gold-silver-zinc-lead mine amounted to 31,000 ounces of gold, 523,000 ounces of silver, 3.6 million pounds of lead, and 14.4 million pounds of zinc. The company forecast 1988 gold production at 85,000 ounces. Expansions at Pegasus' other Montana gold mine, the Zortman-Landusky open pit heap-leaching facility in Phillips County, reportedly led to the production of 106,900 ounces of gold and nearly 203,000 ounces of silver from over 9.6 million tons of ore mined and loaded for leaching. Gold production during 1986 was about 86,000 ounces. The 1987 expansion included the addition of a new carbon adsorption plant and improvements that extended the leaching season to 11 months. Following 4 years of exploration and engineering studies at its Beal project near Fairmont Springs, Silver Bow County, Pegasus announced that development was initiated toward a 1988 startup. The new open pit heap-leaching operation was expected to produce 35,000 ounces of gold annually.

The State's second largest gold mine, Placer Dome U.S. Inc.'s Golden Sunlight Mine at Whitehall, reportedly produced nearly 90,000 ounces of gold and 300,000 ounces of silver in 1987. A new $4.5 million sand tailings treatment plant contributed 6,700 ounces to the overall recovery at the Jefferson County facility. A slight decline in production from that of 1986 reportedly related to lower grade ore encountered when systematic mining was shifted to another area of the ore body.

In Fergus County, the Appaloosa Joint Venture, consisting of Chelsea Resources Ltd. and Cimarron Exploration Inc., poured its first gold at the Spotted Horse Mine during August. Head grades entering the 50-ton-per-day cyanide mill were reportedly expected to average over 1.0 ounce of gold per ton.

At the Jardine Joint Venture in Southern Park County, equal partners Homestake and American Copper and Nickel Co. Inc. completed an underground exploration and engineering studies program and moved toward construction of an underground mine capable of producing 42,000 ounces per year when production begins in mid-1989.

The State reported that placer mining activity was widespread during 1987, but that many small operations were forced to shut down early owing to a lack of water. Nevertheless, placer operations were reportedly conducted along the following drainages: Grasshopper Creek near Bannack, Quartz Creek east of Superior, Sauerkraut Creek near Lincoln, Washington Gulch southeast of Avon, and Brown's Gulch west of Nevada City. Indian Creek west of Townsend was the site of the largest concentration of placer operations.

In addition to the developed and developing mines outlined above, exploration and/or preproduction development was conducted on numerous properties including the Hog Heaven project in Flathead County; Chartam Mine in Broadwater County; Lincoln project (Big Blackfoot), Cruse-Belmont; Pauper's Dream Mines in Lewis and Clark County; Tzarena and Rainbow projects in Silver Bow County; Bagdad Mine in Granite County; Elkhorn Mine in Jefferson County; and the Gold Coin Mine in Deer Lodge County.

Nevada.—In 1987, 13 of the 25 leading domestic gold mines were in Nevada. That State has registered a tenfold increase in gold production since 1979. The increased precious metals mining and exploration activity, combined with the associated growth of the parallel service industry has, for some communities, reportedly begun to strain the capacity of existing community services in some areas. According to State data, employment in the precious metals sector had increased from about 4,100 in 1983 to more than 5,900 by late 1987.

Some of the gold mines reported to have begun or resumed production in 1987 include the Chimney Creek Mine of Goldfields Mining Corp., the Gold Bar Mine of Atlas Gold Mining Inc., the Lewis Mine owned by Hycroft Resources & Development Corp., the Illipah Mine of Echo Bay, the Tuscarora (formerly Dexter) Mine of Horizon Gold Shares Inc. and Fischer-Watt Gold Co., the Big Springs Mine belonging to Freeport-McMoRan Gold Co. and FMC Gold Corp., the Kingston (Victorine) Mine of Nevada Goldfields Corp., the Silver Sun project of the Federal Claim Staking Agency Inc., and the Surprise Mine owned by BMG.

The Chimney Creek Mine in Humboldt County began production in December at an annual rate of 150,000 ounces per year. Open pit mining with milling, heap-leaching, and carbon-in-pulp recovery is employed. The Atlas Gold open pit Gold Bar Mine began mining in January 1987 and poured its first gold in January 1988. Gold recovery was by milling and heap leaching followed by agitated carbon-in-leach recovery. Production at this Eureka County mine

was expected to be 45,000 to 50,000 ounces per year. Atlas Gold reported that exploration and drilling on its Gold Bar block several miles northeast of the mine revealed several areas containing gold mineralization. Vancouver, British Columbia-based Granges Exploration Ltd.'s Lewis Mine and the adjoining Crofoot Mine (also controlled by Granges Ltd.) in Humboldt County were expected to yield a combined 80,000 ounces per year. The Lewis began production in June and the Crofoot, under construction at yearend, poured its first gold bar in early 1988. The open pit Illipah Mine, Echo Bay's seventh gold mine in North America, began production in October and was expected to yield 30,000 ounces per year. The mine, in White Pine County, recovers gold using heap-leaching and carbon-in-pulp methods. The Tuscarora Mine at the town of Tuscarora in Elko County is an open pit and heap-leaching operation with an estimated annual production rate of 5,000 to 14,000 ounces. It began production in November.

In Elko County, Freeport-McMoRan's Big Spring Mine, consisting of two open pits with heap leaching, produced its first gold in October. At the company's Jerritt Canyon Mine nearby, mill throughput was increased by 13%. Combined with improved recovery, this increase resulted in a 17% increase in 1987 gold production to 316,000 ounces. The Jerritt Canyon operation consisted of two open pits. A third pit was due to be opened in 1988. In addition to milling, heap leaching is also employed to effect recovery from lower grade ore. Nevada Goldfields, a wholly owned subsidiary of Golconda Minerals NL of Western Australia, completed construction of its 600-ton-per-day mill at the Kingston project in Lander County. It poured its first gold in April. The newly reopened underground operation was expected to yield 49,000 ounces in 1988. At the company's Aurora Mine in Mineral County, construction of a new 300-ton-per-day mill was completed in December. Open pit and underground mining were used to effect an expected yield of 81,000 ounces of gold and 193,000 ounces of silver over the next 5 years. In August, BMG placed its new Surprise Mine into production. Surprise was the first of a number of satellite ore bodies to be developed at the company's Fortitude Mine in Lander County. The combined 1987 output from the Fortitude and Surprise was about 257,000 ounces. Cash costs at the BMG operation amounted to $121 per equivalent ounce (with byproduct silver converted to equivalent ounces of gold) in 1987. This compares with $144 per equivalent ounce in 1986 and $177 in 1985. The Silver Sun project near Silver Peak in Esmeralda County reportedly began heap leaching in late May.

Favorable gold prices and continued successes with exploration aimed at expanding ore reserves encouraged a number of companies to expand their production capacity. In its 5-year business plans Newmont Gold Co. (NGC), the Nation's largest gold producer in 1987, began a new $400 million capital investment program to substantially increase production at its Carlin gold properties in Eureka County. A planned 50% increase in production to 930,000 ounces of gold in 1988, reaching 1.6 million ounces in 1991, will be sustained from open pit ore deposits now under development. The planned gain in gold production will result from expansions of the two existing mills at NGC's property, completion of a third mill and a leach facility now under construction at the Rain ore body, and construction in 1988-89 of a fourth mill in the northern area of the 400-square-mile property in northeastern Nevada in 1988-89. Leaching of low-grade ore will also be expanded from the current 8 million tons per year to more than 20 million tons per year. During 1987, NGC, processing newly mined and stockpiled ore, produced 589,000 ounces of gold from its Carlin area mines. Near yearend, NGC announced a significant increase in its gold reserves to 15 million ounces from 12.3 million ounces reported at yearend 1986. Exploration drilling in the Deep Post ore body in the northern area of its property and below the shallow ore body at Post encountered mineralization that assayed 0.93 ounce per ton over an interval of 470 feet. This hole, one of several 2,000-foot-deep holes drilled at Deep Post, reportedly provided the richest drill-hole assay over so long an interval in the history of exploration in NGC's vast Nevada holdings.

At the Round Mountain Mine in Nye County, the mine's owners, Echo Bay, Homestake, and Case Pomeroy & Co., announced plans to double the mine's output to 300,000 ounces per year by 1989 at a cost of $140 million. Round Mountain, reportedly the world's largest heap-leaching operation, produced nearly 191,000 ounces in 1987. In White Pine County, Amselco Minerals and Nerco Minerals Co. disclosed plans to construct a new 1,000-ton-per-day mill to process the carboniferous ore fraction segregated during operation at the ongoing 60,000 to 100,000-ounce-per-year Alligator Ridge Mine.

In Humboldt County, AMAX Inc. initiated a $14 million expansion program at its

Sleeper Mine. The expansion, when completed in 1988, was expected to boost annual gold production by about 40% to almost 200,000 ounces. Components of the expansion include the addition of a second open pit and a large increase in heap-leaching capacity. Near yearend, Silver State Mining Corp. announced plans to triple gold production at its Nevada mines. In addition to a new 16,000-ounce-per-year mine scheduled to begin in White Pine County in 1988, the company plans to expand the existing operations at its Tonkin Springs Mine in Eureka County to produce 50,000 ounces per year. Part of the expansion was to include the construction of the Nation's first commercial bioleaching facility. The new facility, under construction at yearend, was designed to exploit the mine's substantial reserves of gold contained in sulfide mineralization. Silver State also holds a 29.3% interest in the Dee Mine, a 50,000-ounce-per-year producer in Elko County.

As geologists learn more about the characteristics and occurrence of gold deposits in Nevada, their discovery rate continues to grow. Exploration along the so-called Carlin trend or gold belt, a highly mineralized zone extending northwest through and beyond NGC's Elko County deposits, led in 1987 to several significant discoveries, including NGC's Deep Post ore body mentioned above. Exploration and deep drilling on the adjoining Goldstrike property owned by American Barrick Resources Corp. led to the discovery of a major deep-seated, high-grade, gold-bearing sulfide deposit. The result was to increase Barrick's Goldstrike reserves from 625,000 ounces to 10 million ounces or possibly more. The deep deposit underlying the Goldstrike operations, where over 40,000 ounces was produced by heap leaching of low-grade surface deposits during 1987, has been designated as the Betze-Post deposit. Because this deposit extends to the southeast onto NGC land, the two companies have concluded a mutual layback agreement. Negotiations were under way at yearend for the joint mining of the new discovery. Forty miles to the southwest, another apparent gold belt paralleling the Carlin trend extends through the area hosting the Gold Bar and Tonkin Springs Mines northwestward through numerous other properties including Battle Mountain's Fortitude deposits. As if to lend additional support for the existence of a second gold belt, reportedly called the Battle Mountain trend, Echo Bay announced in early 1987 that exploration on its McCoy property near Battle Mountain had located a large deposit of precious metals. Incomplete exploration of the find, known as the Cove discovery, had by yearend demonstrated ore reserves bearing 2.1 million ounces of gold and 97.7 million ounces of silver. Before the end of 1987, Echo Bay had opened a surface mine on the lower grade open portion of the Cove deposit and heap leaching of the ore was under way at yearend. Cove reportedly will eventually consist of both an open pit and an underground mine. Construction of a new mill to process ore from both the McCoy and the Cove was also under way at yearend.

New Nevada gold mines completing their first full year of production included the Hog Ranch, Weepah, Austin Gold Venture, Paradise Peak, Florida Canyon, Relief Canyon, Sleeper, and McCoy.

Oregon.—Gold mining and exploration in Oregon during 1987 increased over that of 1986, according to a summary report prepared by the Oregon Department of Geology and Mineral Industries.[8]

There were 20, mostly small, lode and placer mines producing gold during 1987. Active lode mines included the following: the Virtue, Lower Grandview, Golden Eagle, Iron Dyke, and Gold Ridge in Baker County; the Greenback and the Gold Blanket in Josephine County; the Maid of the Mist in Jackson County; the Oregon King (a heap-leaching operation) in Jefferson County; the Pyx in Grant County; and the Ruth in Marion County. The largest of these mines, the Iron Dyke of Silver King Mines Inc., reportedly produced 15,000 tons of copper-gold-silver ore that was trucked to the Silver King mill at Cuprum, ID.

Active placer mines included the Bonanza Creek Co. placer on Pine Creek in Baker County, the State's largest placer operation. Goldwater Inc.'s placer, also on Pine Creek, reportedly has been active for about 6 months per year for several years. The Broken Pick placer has also been recovering gold for several years in Baker County. Small placer operations were also active along Josephine Creek, Sucker Creek, Coyote Creek, Lower Grave Creek, and Galice Creek, all in Josephine County; and along Coffee Creek in Douglas County.

An epithermal deposit undergoing extensive exploration and drilling was the Quartz Mountain gold property in Lake County near the California border, where Quartz Mountain Gold Corp. and Galactic Resources had reportedly drilled 460 holes by yearend. Five high-grade areas were reportedly delineated within two separate deposits: the Crone Hill deposit and the Quartz Butte deposit. Drill-proven and probable reserves on the property were reported

to be in excess of 2.0 million ounces at yearend. The company also had several other nearby deposits under investigation at yearend.

**South Carolina.**—In Chesterfield County near Jefferson, Westmont Mining Inc., a Denver, CO-based subsidiary of the Costain Group PLC of the United Kingdom, reportedly poured its first gold in August following earlier heap-leaching tests at its recently reopened Brewer Mine. The open pit Brewer is one of several permitted gold mines in the State. Westmont began heap leaching in late November and expected to recover 150,000 ounces of gold during the planned 6-year life of the mine. Plant and equipment costs reportedly totaled about $8 million.

At the Haile Mine in Lancaster County, opened in 1985, Piedmont Mining Corp. reported producing 7,836 ounces of gold and 5,708 ounces of silver from nearly 250,000 tons of ore mined and still being leached at yearend. Exploration at the new open pit heap-leaching mine during the year resulted in a 56% increase in proven and probable ore reserves to about 1.6 million tons averaging 0.056 ounce per ton.

Piedmont also controls the nearby Blackmon Mine and a number of former gold-producing properties in southern North Carolina. In 1987, Piedmont introduced its Piedmont Gold Piece, a one-half ounce, 9999-fine commemorative piece celebrating the rebirth of gold mining in the southeast. Gold for the new medallion was recovered from the Haile Mine.

In August, Ridgeway Mining Co., controlled by BP Minerals America Inc. and Galactic Resources, received the final permits to proceed with construction of its Ridgeway gold mine, 4 miles east of Ridgeway in Fairfield County. An environmental group immediately filed suit challenging the decision by State authorities to issue the permits. At yearend, the case was nearing a resolution that would allow the mine to proceed. In the meantime, construction of the facility began in September and was continuing at yearend. Beginning in late 1988 or early 1989, the 1,800-acre facility was expected to produce 133,000 ounces per year for 10 or more years. Open pit mining with conventional carbon-in-pulp milling and heap leaching will be employed. At a capital cost of about $94 million, the new mine is expected to employ close to 200 people.

Other companies exploring, mostly for gold, in the State included Amselco Minerals, Billiton Exploration, Newmont Minerals Co., St. Joe Gold Inc., Texasgulf, American Copper, Boise Cascade Co., and FMC.

**South Dakota.**—A task force appointed by the Governor convened to draft new mining rules aimed at enforcing the reclamation of surfaced-mined areas and to supplement laws passed earlier by the State legislature. The State Board of Minerals and Environment passed the draft regulations.

On January 14, the Governor unveiled that State's new gold South Dakota Centennial Medallion. In April, the State entered the gold bullion market with its new 999-fine gold "Bison" medallion. The gold for both pieces was mined at the Homestake Mine at Lead.

At the Homestake Mine in Lawrence County, the Nation's largest underground gold mine, Homestake reported milling 2.3 million tons of ore yielding 326,000 ounces of gold. Owing to the installation of a new gravity-separation circuit in midyear, the overall gold recovery percentage was increased slightly from that of 1986. Homestake's average cash costs increased to $328 per ounce from $285 in 1986, chiefly because of a decline in underground ore grade and expenses related to prestripping costs at the mine's Open Cut operation. The Open Cut became fully operational during the year with the startup of crushing and conveying facilities. Underground and surface exploration added 2.9 million tons of ore to reserves, more than replacing ore mined during 1987.

St. Joe Gold announced its intentions to proceed with development of its Richmond Hill gold mine, 5 miles northwest of Lead in Lawrence County. The proposed open pit heap-leaching operation, expected to begin in early 1988, would be mined at a rate of up to 2 million tons per year over a 10-year period.

In midyear, Brohm Resources Inc. began construction of a heap-leaching facility, to be followed by construction of an oxide heap-leaching facility and a conventional milling plant to process sulfide ores at its Gilt Edge Mine near Galena in Lawrence County. Production was expected to begin in July 1988 at a rate of about 42,000 ounces per year.

Also in Lawrence County, Wharf Resources (USA) Inc. reportedly recovered 46,000 ounces of gold at its open pit heap-leaching operation near Terry Peak. In the fall, Wharf added a third heap-leaching pad and was expecting metal recovery to re-

sume in 1988 from the Annie Creek portion of the open pit. Near yearend, the company proposed adding a fourth heap-leach pad, subject to approval of permitting agencies. To the south near Deer Mountain, Golden Reward Mining Co. continued plans to open a $30 million open pit mine at its Golden Reward Property, also scheduled to begin production in 1988.

Goldstake Explorations (SD) Inc. announced its intentions to process about 5 million tons of old gold-bearing tailings along an 18-mile stretch of Whitewood Creek in Mead County south of Whitewood. The operation, using gravity-concentration and leaching-recovery techniques, will be conducted by Goldstake and its partner, Strawberry Hill Mining Co. of Deadwood, SD. Production at an expected rate of about 42,000 ounces per year was scheduled to begin in 1988.

Utah.—Following several years of an ongoing $400 million modernization project due for completion in mid-1988, the giant Bingham Canyon Mine, near Salt Lake City, completed its first full year of copper and byproduct gold and silver production. The mine was the Nation's sixth largest gold producer in 1987. The mine's owner, BP Minerals, expects, upon completion of the modernization program, to produce annually 300,000 ounces of gold, 2.3 million ounces of silver, 190,000 tons of copper, and 12 million pounds of molybdenum.

Gold production from the Mercur Mine, near Tooele, was over 108,000 ounces in 1987. Dump leaching contributed nearly 11,500 ounces of production to the total. Mercur's average cash cost in 1987 was $216 per ounce, compared with $199 per ounce in 1986. The higher 1987 costs were attributed to treatment of marginally lower grades during the year. In 1987, the mine's owner, Barrick, spent over $17 million on the construction of a 750-ton-per-day autoclave circuit, to treat refractory ore, plus other improvements to the overall operations. Gold recovery from the mine's refractory ore fraction using the new autoclave reportedly will be increased to over 85%. During the year Barrick acquired a 50% interest in the Barney's Canyon area, 20 miles to the north. Favorable exploration there in 1987 by Barrick and its partner Royal Minerals Inc. was to be followed by drilling in 1988.

Tenneco Minerals Co. reportedly planned to reenter the precious metals mining business by developing its Goldstrike project in the Bull Valley mining district of Washington County. Tenneco sold its Nevada gold properties: Borealis, Manhattan, and McCoy in 1986 to Echo Bay.

Washington.—Gold production at 210,000 ounces surpassed record-high level of 154,000 ounces in 1986, according to a review published by the State.[9]

Revisions to Washington's laws governing the leasing of State-owned land were adopted on October 9, 1987, and became effective November 10, 1987. The major changes applied to the annual rental, advance minimum royalty payments, term length for prospecting leases, and the ability of the State Department of Natural Resources to use public auction procedures to issue placer gold mining contracts and to designate areas for recreational prospecting. A plan outlining proposed operations, a new requirement, was added and must be approved prior to beginning prospecting.

Production at the State's largest gold mine, the Cannon Mine in Chelan County, owned by Asamera Minerals (U.S.) Inc. and Breakwater Resources Ltd., amounted to a record high 136,913 ounces of gold and 184,000 ounces of silver during the fiscal year ending September 30. The large underground mine at Wenatchee employing nearly 200 people, milled 487,006 tons bearing an average grade of 0.308 ounce of gold per ton. Modifications to the mill in 1986 resulted in an increase in gold recovery from 86% to 91%. The mill product is shipped to Japan and Montana for smelting and gold recovery.

The State's second largest mine, Hecla's Republic Unit (Knob Hill) at Republic in Ferry County, reported producing 70,095 ounces of gold and 341,272 ounces of silver. Average ore grades increased significantly during 1987 as mining moved into the recently discovered higher grade Golden Promise area of the mine. The recovered grade was up 43% to 0.97 ounce of gold per ton compared with 0.68 ounce per ton in 1986. Republic's silver output more than doubled in 1987. Proven and probable ore reserve tonnage increased 38% during the same period. Also in Ferry County, the Valley Mine, operated by High Country Mining and Exploration, completed its first full year of underground mining in September. Other Ferry County mines included the South Penn and the Gold Dike Mines. At the South Penn, Chemgold Inc., a subsidiary of Glamis Gold Ltd., and its partner Crown Resources Corp. reported mining 33,000 tons of ore grading 0.08 ounce per ton. The partners expected to recover about 900 ounces of gold during the 2-year life of the project. At the Gold Dike Mine east of

Danville, Vulcan Mountain Co. resumed mining and heap-leach recovery. Toward the end of the year, Vulcan and Sundance Mining Development Inc. signed an exploration agreement with U.S. Borax and Chemical Corp. covering the Gold Dike property and the adjoining Gold Hill property.

According to the State review, a minimum of 55 companies and individuals explored for metals in Washington State during 1987. Nearly all of these reportedly explored for gold and silver.

Other States.—In Wyoming, placer operations were reportedly recovering gold from various drainages in the Atlantic City-South Pass area.[10] Consolidated McKinney Resources Inc. of Vancouver, Canada, reportedly began drilling near the Old Carissa Mine in the South Pass area south of Lander, WY. Northeast of the Carissa Mine and also in Freemont County, the Gyorvary Mining Co. reportedly began construction on an addition to its mill at the Mary Ellen Mine. In southeastern Wyoming, exploration work was also reportedly under way around old workings in the Medicine Bow Mountains.

In Minnesota, the State's mining tax laws were revised during 1987 and were expected to stimulate mining and encourage increased exploration activity. Over 900,000 acres of land was leased from the State during 1987, and reportedly there were 27 companies conducting exploration and drilling, principally for gold.

Mineralco Inc. of Ottawa, IL, had been exploring for gold in the vicinity of Hixon Lake in Oneida County south of Rhinelander, WI, for several years. Mineralco's request for a permit to drill test holes beneath the lake was denied by State authorities at yearend. Toward yearend, Kennecott announced that it planned to seek State and local permits to develop a copper-gold-silver deposit at its Flambeau property in Rusk County near Ladysmith. CoCa Mines Inc. retained its 65% interest in the Raspberry Gold Prospect in northern Minnesota. Further exploration was planned for 1988.

At Callahan Mining Corp.'s Ropes gold mine near Ishpeming, MI, gold mining proceeded into the second full year of operation. Callahan reported milling nearly 670,000 tons of ore averaging 0.079 ounce of gold per ton and 0.199 ounce of silver per ton during 1987. Metal sales during the year amounted to 43,453 ounces of gold and 58,814 ounces of silver.

In Maine, Scintilore Explorations Ltd. of Ontario, Canada, reportedly continued work at its Big Hill silver-zinc-gold deposit at Pembroke, Washington County, east of Portland.

**Table 4.—Mine production of gold in the United States, by month**

(Troy ounces)

| Month | 1983 | 1984 | 1985 | 1986[r] | 1987 |
|---|---|---|---|---|---|
| January | 134,435 | 140,586 | 174,916 | 286,427 | 382,389 |
| February | 131,636 | 144,945 | 175,486 | 288,372 | 385,088 |
| March | 153,806 | 174,242 | 204,492 | 295,941 | 395,701 |
| April | 162,224 | 166,906 | 192,930 | 315,556 | 412,902 |
| May | 179,950 | 183,068 | 193,326 | 310,003 | 416,780 |
| June | 178,929 | 195,337 | 191,202 | 325,925 | 420,181 |
| July | 179,521 | 186,620 | 198,189 | 317,392 | 420,219 |
| August | 192,095 | 183,123 | 200,682 | 327,663 | 423,006 |
| September | 189,237 | 178,483 | 235,618 | 327,864 | 430,158 |
| October | 183,534 | 186,413 | 230,586 | 323,708 | 428,511 |
| November | 165,903 | 174,313 | 226,005 | 310,089 | 420,276 |
| December | 151,264 | 170,577 | 222,780 | 310,250 | 441,171 |
| Total | 2,002,536 | 2,084,613 | 2,447,232 | 3,739,013 | 4,966,392 |

[r]Revised.

**Table 5.—Twenty-five leading gold-producing mines in the United States in 1987, in *order of output***

| Rank | Mine | County and State | Operator | Source of gold |
|---|---|---|---|---|
| 1 | Carlin Mines Complex | Eureka, NV | Newmont Gold Co | Gold ore |
| 2 | Homestake | Lawrence, SD | Homestake Mining Co | Do. |
| 3 | Jerritt Canyon (Enfield Bell) | Elko, NV | Freeport-McMoRan Gold Co | Do. |
| 4 | Portrero and Surprise | Lander, NV | Battle Mountain Gold Co | Do. |
| 5 | Mesquite | Imperial, CA | Goldfields Mining Co | Do. |
| 6 | Bingham Canyon | Salt Lake, UT | Kennecott-Utah Copper Div. | Copper ore |
| 7 | Round Mountain | Nye, NV | Round Mountain Gold Corp | Gold ore |
| 8 | McLaughlin | Napa, CA | Homestake Mining Co | Do. |
| 9 | Paradise Peak | Nye, NV | FMC Gold Co | Do. |
| 10 | Getchell | Humboldt, NV | Amax Gold Inc | Do. |
| 11 | Cannon | Chelan, WA | Asamera Minerals (U.S.) Inc | Do. |
| 12 | Mercur | Tooele, UT | Barrick Mercur Gold Mines Inc | Do. |
| 13 | Zortman-Landusky | Phillips, MT | Pegasus Gold Inc | Do. |
| 14 | McCoy | Lander, NV | Echo Bay Mining Co | Do. |
| 15 | Golden Sunlight | Jefferson, MT | Golden Sunlight Mines Inc | Do. |
| 16 | New Summitville | Rio Grande, CO | Summitville Consolidated Mining Co. Inc | Do. |
| 17 | Republic Unit | Ferry, WA | Hecla Mining Co | Do. |
| 18 | Foley Ridge and Annie Creek | Lawrence, SD | Wharf Resources (U.S.A.) Inc | Do. |
| 19 | Dee | Elko, NV | Dee Gold Mining Co | Do. |
| 20 | Jamestown | Tuolumne, CA | Sonora Mining Corp | Do. |
| 21 | Pinson and Preble | Humboldt, NV | Pinson Mining Co | Do. |
| 22 | Horse Canyon (Cortez) | Eureka, NV | Cortez Gold Mines | Do. |
| 23 | Florida Canyon | Pershing, NV | Florida Canyon Mining Co | Do. |
| 24 | Star-Pointer | White Pine, NV | Silver King Mines Inc | Do. |
| 25 | Bald Mountain | Eureka, NV | Placer Dome (U.S.) Inc | Do. |

## Table 6.—Gold produced in the United States, by State, type of mine, and class of ore

| Year and State | Placer (troy ounces of gold) | Lode: Gold ore | | Lode: Gold-silver ore | | Lode: Silver ore | |
|---|---|---|---|---|---|---|---|
| | | Short tons | Troy ounces of gold | Short tons | Troy ounces of gold | Short tons | Troy ounces of gold |
| 1903 | 58,337 | 24,141,617 | 1,393,406 | 1,124,556 | 48,445 | 7,512,561 | 35,057 |
| 1904 | 57,597 | 30,497,362 | 1,736,998 | 1,587,830 | 55,362 | 4,389,945 | 20,795 |
| 1905 | 73,350 | 35,906,018 | 2,179,920 | 1,043,854 | 41,201 | 3,896,130 | 21,268 |
| 1906 | r73,331 | r30,682,634 | 2,543,557 | 969,099 | 39,399 | 5,522,018 | 22,397 |
| 1907: | | | | | | | |
| Alaska | W | W | W | -- | -- | -- | -- |
| Arizona | W | W | W | -- | -- | -- | -- |
| California | 23,463 | 10,842,152 | 579,142 | -- | -- | -- | -- |
| Colorado | 2 | 4,126,225 | 162,365 | -- | -- | -- | -- |
| Idaho | -- | W | W | W | W | W | W |
| Michigan | -- | W | W | -- | -- | W | W |
| Montana | W | 14,286,880 | 282,883 | -- | -- | -- | -- |
| Nevada | 20,133 | 45,096,541 | 2,619,809 | W | W | 8,180,597 | 37,496 |
| New Mexico | -- | 17,086 | 291 | -- | -- | -- | -- |
| Oregon | W | W | W | -- | -- | -- | -- |
| South Carolina | -- | W | W | -- | -- | -- | -- |
| South Dakota | -- | W | W | -- | -- | W | W |
| Utah | -- | W | W | -- | -- | -- | -- |
| Washington | -- | W | W | -- | -- | -- | -- |
| Total[2] | 162,386 | 89,271,030 | 4,450,076 | W | W | 8,696,125 | 39,415 |
| Percent of total gold | 3 | XX | 90 | XX | W | XX | 1 |

| Year and State | Lode: Copper ore | | Lode: Other[3] | | Total[1] | |
|---|---|---|---|---|---|---|
| | Short tons | Troy ounces of gold | Short tons | Troy ounces of gold | Short tons | Troy ounces of gold |
| 1903 | 137,668,016 | 258,222 | 858,749 | 19,599 | 171,305,189 | 2,002,826 |
| 1904 | 182,899,873 | 199,720 | 472,359 | 30,124 | 169,856,369 | 1,984,615 |
| 1904 | 149,464,862 | 74,688 | 4,476,694 | 35,291 | 194,729,443 | 4,427,252 |
| 1905 | 116,775,362 | r52,811 | 284,982 | 18,710 | r194,194,845 | r3,739,015 |

See footnotes at end of table.

**Table 6.—Gold produced in the United States, by State, type of mine, and class of ore —Continued**

| | Lode | | | | Total[1] | |
|---|---|---|---|---|---|---|
| | Copper ore | | Other[2] | | | |
| | Short tons | Troy ounces of gold | Short tons | Troy ounces of gold | Short tons | Troy ounces of gold |
| 1987 | | | | | | |
| Alaska | 102,867,487 | 48,430 | W | W | 102,709,284 | 96,540 |
| Arizona | -- | -- | -- | -- | 10,842,152 | 692,895 |
| California | -- | -- | 219,208 | 16,609 | 4,346,407 | 173,795 |
| Colorado | W | W | -- | -- | 2,586,697 | 97,773 |
| Idaho | -- | -- | -- | -- | W | W |
| Michigan | 8,144,140 | 287 | W | W | 17,488,284 | 284,305 |
| Montana | -- | -- | 62 | 2,022 | 84,246,291 | 2,679,470 |
| Nevada | W | W | -- | -- | W | W |
| New Mexico | -- | -- | -- | -- | W | W |
| Oregon | -- | -- | -- | -- | W | W |
| South Carolina | -- | -- | -- | -- | W | W |
| South Dakota | W | W | -- | -- | W | W |
| Utah | -- | -- | -- | -- | W | W |
| Washington | -- | -- | -- | -- | W | W |
| Total[3] | 221,702,975 | 261,228 | W | W | 314,996,178 | 4,946,302 |
| Percent of total gold | XX | 5 | XX | W | XX | 100 |

[1]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[2]Data may not add to totals shown because of items withheld to avoid disclosing company proprietary data.
[3]Includes lead, zinc, copper-lead, lead-zinc, copper-zinc, copper-lead-zinc ores, and old tailings, etc.

## Table 7.—Lode gold produced in the United States, by State

| Year and State | Amalgamation | | Cyanidation | | Smelting of concentrates | | | Smelting of ore | | Total ore processed[1] (short tons) | Total gold recovered (troy ounces) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ore treated (short tons) | Gold recovered (troy ounces) | Ore treated (short tons) | Gold recovered (troy ounces) | Ore concentrated (short tons) | Concentrates smelted (short tons) | Gold recovered (troy ounces) | Ore smelted (short tons) | Gold recovered (troy ounces) | | |
| 1963 | 127,655 | 24,680 | 28,415,818 | 1,631,606 | 142,546,432 | 3,044,307 | 306,609 | 205,291 | [2]2,996 | 171,306,196 | [3]1,972,982 |
| 1964 | 124,983 | 23,274 | 34,902,191 | 1,752,492 | 134,735,157 | 3,605,791 | 257,238 | 75,958 | [3]14,214 | 169,838,389 | [3]2,047,218 |
| 1965 | 20,812 | 3,741 | 39,502,183 | 2,082,515 | 154,886,128 | 3,220,471 | 231,706 | 221,315 | [3]34,179 | 194,730,448 | [3]2,358,441 |
| 1966 | 850,296 | 23,719 | [r]64,666,550 | 3,317,244 | 118,529,487 | 2,838,702 | [3]262,708 | 148,572 | [3]3,455 | [r]184,194,845 | [3]3,888,112 |
| 1967: | | | | | | | | | | | |
| Alaska | -- | -- | W | W | -- | -- | -- | -- | -- | W | W |
| Arizona | -- | -- | W | W | 162,[illegible]87,487 | 2,374,538 | 49,155 | W | W | 162,788,294 | [3]65,249 |
| California | W | W | 9,419,527 | 520,738 | W | W | W | -- | -- | 10,842,152 | 573,142 |
| Colorado | W | W | W | W | W | W | W | W | W | 4,505,269 | 178,798 |
| Idaho | -- | -- | 2,129,911 | 94,490 | W | W | W | W | W | 2,536,097 | 97,773 |
| Michigan | -- | -- | W | W | -- | -- | -- | -- | -- | W | W |
| Montana | -- | -- | W | W | -- | -- | -- | -- | -- | 17,433,284 | [3]324,365 |
| Nevada | -- | -- | 12,751,923 | 210,592 | W | W | W | W | W | 53,246,261 | 2,650,337 |
| New Mexico | -- | -- | 52,921,139 | 2,623,355 | W | W | W | W | W | W | W |
| Oregon | W | W | W | W | W | W | W | W | W | W | W |
| South Carolina | -- | -- | -- | -- | -- | -- | -- | W | W | W | W |
| South Dakota | -- | -- | W | W | -- | -- | -- | -- | -- | W | W |
| Utah | -- | -- | W | W | W | W | W | W | W | W | W |
| Washington | -- | -- | W | W | W | W | W | -- | -- | W | W |
| Total | W | W | 88,430,702 | 4,194,564 | 216,889,426 | 4,060,599 | 362,447 | W | W | 314,905,178 | 4,992,987 |

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes old tailings and some non-gold-bearing ores not reparable, in amounts ranging from 0.15% to 0.25% of the totals for the year stated.
[2]Includes some placer production to avoid disclosing company proprietary data.

## Table 8.—Gold produced in the United States by cyanidation[1]

| Year | Extraction in vats, tanks, and closed containers[2] | | Leaching in open heaps or dumps[3] | |
|---|---|---|---|---|
| | Ore treated (short tons) | Gold recovered[4] (troy ounces) | Ore treated (short tons) | Gold recovered (troy ounces) |
| 1983 | 11,317,285 | 1,606,205 | 17,098,533 | 545,403 |
| 1984 | 13,503,143 | 1,163,803 | 21,299,048 | 584,509 |
| 1985 | 20,542,717 | 1,555,835 | 19,059,498 | 532,980 |
| 1986 | r27,106,861 | 2,358,641 | 37,559,039 | 996,603 |
| 1987 | 32,754,902 | 2,404,498 | 65,675,770 | 1,790,161 |

rRevised.
[1]May include small quantities recovered by leaching with thiourea, by bioextraction, and by proprietary processes.
[2]Includes autoclaves.
[3]May include tailings and waste ore dumps.
[4]May include small quantities recovered by gravity methods.

## Table 9.—Gold produced at placer mines in the United States, by method of recovery[1]

| Method of recovery | Mines producing | Washing plants | Material washed (thousand cubic yards) | Gold recoverable | | |
|---|---|---|---|---|---|---|
| | | | | Quantity (thousand troy ounces) | Value (thousands) | Average value per cubic yard |
| **Bucketline dredging:** | | | | | | |
| 1983 | 3 | 4 | 4,785 | 30 | $12,512 | $2.615 |
| 1984 | 2 | 3 | 4,840 | 29 | 10,397 | 2.147 |
| 1985 | 3 | 4 | 3,958 | 32 | 10,185 | 2.573 |
| 1986 | 3 | 4 | 4,061 | 30 | 11,227 | 2.751 |
| 1987 | 4 | 5 | 9,233 | 112 | 49,989 | 5.356 |
| **Dragline dredging:** | | | | | | |
| 1983 | 2 | 13 | r110 | r3 | 1,333 | 3.481 |
| 1984 | 4 | 13 | r126 | r4 | 1,593 | r2.908 |
| 1985 | 3 | 14 | r156 | r4 | 1,348 | r2.224 |
| 1986 | 3 | 14 | r14 | r4 | 1,342 | r12.862 |
| 1987 | 3 | 3 | r93 | r2 | 971 | r6.262 |
| **Hydraulicking:** | | | | | | |
| 1983 | 1 | 1 | 3 | (2) | 117 | 43.342 |
| 1984 | 1 | 1 | 28 | (2) | 90 | 3.220 |
| 1985 | -- | -- | -- | -- | -- | -- |
| 1986 | 1 | 1 | 100 | (2) | 17 | .166 |
| 1987 | -- | -- | -- | -- | -- | -- |
| **Nonfloating washing plants:** | | | | | | |
| 1983 | 6 | 6 | 961 | 18 | 7,450 | 7.750 |
| 1984 | 5 | 5 | 310 | 3 | 1,036 | 3.343 |
| 1985 | 6 | 6 | 959 | 31 | 9,690 | 10.102 |
| 1986 | 4 | 4 | 276 | 25 | 9,244 | 33.528 |
| 1987 | 6 | 6 | 832 | 15 | 6,698 | 8.048 |
| **Underground placer, small-scale mechanical and hand methods, suction dredge:** | | | | | | |
| 1983 | 22 | 24 | r167 | r3 | r1,310 | 7.831 |
| 1984 | 10 | 11 | 197 | 1 | 454 | 2.304 |
| 1985 | 19 | 19 | 621 | 6 | 2,061 | 3.320 |
| 1986 | 24 | 24 | r887 | 14 | r5,175 | r5.833 |
| 1987 | 15 | 15 | 486 | 25 | 15,530 | 32.356 |
| **Total placers:**[3] | | | | | | |
| 1983 | 35 | 48 | r6,026 | r54 | r22,722 | r $3.707 |
| 1984 | 25 | 36 | r5,501 | r39 | 13,569 | r2.242 |
| 1985 | 31 | 43 | r5,894 | r73 | 23,284 | r$3.913 |
| 1986 | 35 | 47 | r r5,358 | r73 | r27,009 | r r4.823 |
| 1987 | 29 | 29 | r10,739 | r183 | 73,188 | r6.816 |

rRevised.
[1]Data are only for those mines that report annually on the Bureau of Mines voluntary survey; there are many more, usually smaller and less well-established operations, mainly in Alaska, that do not report.
[2]Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.
[3]Excludes gold recovered at commercial sand and gravel operations.
[4]Gold recovered as a byproduct at sand and gravel operations is not used in calculating average value per cubic yard.
[5]Less than 1/2 unit.
[6]Data may not add to totals shown because of independent rounding.

**Table 10.—U.S. refinery production of gold[1]**

(Thousand troy ounces)

| Raw material | 1983 | 1984 | 1985 | 1986[r] | 1987 |
|---|---|---|---|---|---|
| Concentrates and ores: Domestic and foreign | 1,972 | 2,101 | 2,078 | 2,306 | 3,613 |
| Old scrap | [r]1,784 | [r]1,769 | [r]1,602 | 1,345 | 2,034 |
| New scrap | 1,357 | 1,543 | 1,510 | 1,618 | 1,273 |
| Total[2] | [r]5,114 | [r]5,413 | [r]5,188 | 5,269 | 6,920 |

[r]Revised.
[1]Data may include estimates.
[2]Data may not add to totals shown because of independent rounding.

## CONSUMPTION AND USES

The use of karat gold in jewelry manufacturing increased 12%, while the industrial use of fine gold for electroplating, principally for electronic applications, increased about 7%. Gold-filled composites used in the industrial sector showed a substantial decline during the year, as did the use of gold in dentistry. The increased demand for karat gold in the jewelry and arts category may reflect increased purchases of domestically fabricated karat gold jewelry in place of imported items, such as gold chain, which became relatively expensive as the U.S. dollar weakened.

The volume of contracts traded on the Nation's futures exchanges increased substantially during the year, with volume on the Commodity Exchange Inc. (COMEX) in New York up by nearly 20% over that of 1986.

On June 16, the Chicago Mercantile Exchange (CME), through its International Monetary Market division, resumed trading gold futures contracts following a nearly 2-year hiatus. The CME's decision to resume trading gold futures (100-ounce contracts) reportedly was prompted in part by growing investor interest in gold as well as by the recent exchange volume overload problems experienced by the New York-based COMEX.

The popularity of the new American Eagle gold coin program was confirmed when the U.S. Mint announced in April that it had exceeded its original 12-month sales projection of 2.2 million coins by 100,000 coins.

**Table 11.—U.S. consumption of gold,[1] by end-use sector[2]**

(Thousand troy ounces)

| End use | 1983[r] | 1984[r] | 1985[r] | 1986[r] | 1987 |
|---|---|---|---|---|---|
| Jewelry and the arts: | | | | | |
| Karat gold | 1,414 | 1,420 | 1,398 | 1,412 | 1,588 |
| Fine gold for electroplating | 21 | 23 | 24 | 86 | 89 |
| Gold-filled and other | 230 | 216 | 216 | 218 | 274 |
| Total[3] | 1,665 | 1,658 | 1,638 | 1,716 | 1,994 |
| Dental | 325 | 305 | 290 | 253 | 225 |
| Industrial: | | | | | |
| Karat gold | 42 | 39 | 39 | 39 | 40 |
| Fine gold for electroplating | 370 | 420 | 381 | 369 | 394 |
| Gold-filled and other | 673 | 675 | 731 | 741 | 673 |
| Total[3] | 1,085 | 1,167 | 1,151 | 1,149 | 1,106 |
| Small items for investment[4] | 3 | 8 | 7 | 6 | 3 |
| Grand total[3] | 3,078 | 3,140 | 3,097 | 3,126 | 3,228 |

[r]Revised.
[1]Gold consumed in fabricated products only; does not include monetary bullion.
[2]Data may include estimates.
[3]Data may not add to totals shown because of independent rounding.
[4]Fabricated bars, medallions, coins, etc.

## STOCKS

**Commercial.**—Stocks of refined bullion held by industrial users at yearend were 21% lower than at yearend 1986. The decline may reflect increased fabrication as well as a reluctance on the part of fabricators to finance inventories in excess of their requirements during a period of relatively strong gold prices. Stocks of gold certified for delivery by COMEX, the Nation's largest futures exchange, declined by about 7% from gold on deposit at yearend 1986. Gold stocks held by other domestic exchanges are small compared with those held by COMEX.

**Table 12.—Yearend stocks of gold in the United States**

(Thousand troy ounces)

| | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| Industry | [r]811 | [r]753 | [r]594 | [r]925 | 732 |
| Futures exchange | 2,580 | 3,359 | [1]2,110 | [1]2,809 | [1]2,625 |
| Department of the Treasury[2] | 263,406 | 262,814 | 262,672 | 262,032 | 262,388 |
| Earmarked gold[3] | 341,402 | 337,228 | 337,399 | 332,733 | 329,678 |

[r]Revised.
[1]Commodity Exchange Inc. only. Stocks held by other exchanges estimated to be less than 2% of totals shown.
[2]Excludes gold in Exchange Stabilization Fund.
[3]Gold held for foreign and international official accounts at New York Federal Reserve Bank.

## PRICES

The annual average U.S. price of gold rose 22% in 1987. The rising prices were generally accompanied by increased trading in gold futures on the Nation's commodity exchanges.

**Table 13.—U.S. gold prices[1]**

(Dollars per troy ounce)

| Period | Low | | High | | Average |
|---|---|---|---|---|---|
| | Price | Date | Price | Date | |
| 1982 | 374.65 | Nov. 21 | 509.25 | Feb. 15 | 424.00 |
| 1984 | 307.90 | Dec. 20 | 406.85 | Mar. 5 | 360.66 |
| 1985 | 284.64 | Feb. 25 | 341.30 | Aug. 19 and 23 | 317.66 |
| 1986 | 326.70 | Jan. 2 | 438.50 | Oct. 3 | 368.24 |
| 1987: | | | | | |
| January | 400.45 | Jan. 5 | 423.83 | Jan. 19 | 409.81 |
| February | 391.51 | Feb. 18 | 408.29 | Feb. 2 | 402.85 |
| March | 405.34 | Mar. 2 | 425.58 | Mar. 30 | 410.46 |
| April | 429.07 | Apr. 7 | 476.44 | Apr. 27 | 440.35 |
| May | 452.64 | May 29 | 476.95 | May 20 | 461.73 |
| June | 439.81 | June 22 | 458.66 | June 11 | 451.23 |
| July | 446.13 | July 7 | 464.17 | July 31 | 452.45 |
| August | 454.95 | Aug. 17 | 475.90 | Aug. 4 | 462.58 |
| September | 455.40 | Sept. 1 | 466.42 | Sept. 4 | 461.78 |
| October | 455.77 | Oct. 2 | 482.47 | Oct. 19 | 466.80 |
| November | 458.98 | Nov. 5 | 493.99 | Nov. 30 | 487.91 |
| December | 478.96 | Dec. 17 | 501.25 | Dec. 14 | 487.68 |
| Year | 391.51 | Feb. 18 | 501.25 | Dec. 14 | 447.95 |

[1]Engelhard Industries daily quotation.

## FOREIGN TRADE

Owing to a precipitous drop in imports, the United States was a net exporter of gold, albeit by the slimmest of margins, for the first time since 1981. As in other recent years, the Nation was a net importer of refined gold and of all gold-containing materials except waste and scrap. The emergence of substantial buying interest on the part of private Taiwanese as well as the Central Bank of Taiwan, combined with the continuing weakening of the U.S. dollar against the Taiwanese dollar, led to a large percentage of refined bullion exports to Taiwan, especially toward yearend.

The quantity of gold contained in imported coins declined for the third consecutive year, reflecting continuing domestic investor interest in domestically minted bullion coins as well as the increasingly effective promotional campaigns by the U.S. Mint.

## Table 14.—U.S. exports of gold, by country[1]

| Year and country | Ore and concentrates[2] | | Waste and scrap | | Doré and precipitates | | Refined bullion | | Total[3] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity (troy ounces) | Value (thousands) | Quantity (troy ounces) | Value (thousands) | Quantity (troy ounces) | Value (thousands) | Quantity (troy ounces) | Value (thousands) | Quantity (troy ounces) | Value (thousands) |
| 1983 | 12,757 | $5,190 | 1,175,830 | $489,780 | 6,213 | $26,037 | 1,881,233 | $626,416 | 3,130,033 | $1,226,434 |
| 1984 | 5,298 | 545 | 1,422,849 | 553,237 | 72,470 | 24,502 | 3,482,473 | 1,284,716 | 4,981,090 | 1,813,992 |
| 1985 | 2,448 | 771 | 980,147 | 308,418 | 95,774 | 30,147 | 2,889,309 | 919,433 | 3,985,678 | 1,253,764 |
| 1986 | 5,344 | 1,589 | 979,089 | 352,471 | 456,267 | 158,005 | r2,554,411 | r1,306,956 | r4,995,091 | r1,819,022 |
| 1987: | | | | | | | | | | |
| Belgium-Luxembourg | -- | -- | 40,922 | 19,157 | -- | -- | 350 | 121 | 41,272 | 19,278 |
| Brazil | -- | -- | -- | -- | -- | -- | 6,658 | 896 | 6,658 | 896 |
| Canada | 13,759 | 6,012 | 265,179 | 111,432 | 412,854 | 177,306 | 774,178 | 332,922 | 1,465,970 | 627,670 |
| France | 87 | 13 | 367,556 | 163,220 | 9,102 | 4,046 | 34,879 | 16,060 | 411,624 | 183,439 |
| Germany, Federal Republic of | -- | -- | 7,506 | 3,177 | 89,485 | 39,093 | 1,855 | 714 | 98,846 | 42,984 |
| Hong Kong | -- | -- | -- | -- | -- | -- | 25,670 | 13,017 | 25,670 | 13,017 |
| Japan | -- | -- | 3,630 | 921 | 4,001 | 1,058 | 3,944 | 1,309 | 11,575 | 3,288 |
| Mexico | -- | -- | 1,370 | 366 | 1,130 | 493 | 5,225 | 2,142 | 7,725 | 3,001 |
| Peru | -- | -- | 417 | 185 | 723 | 400 | 54,641 | 24,460 | 55,781 | 25,045 |
| Sweden | -- | -- | 37,652 | 16,064 | 1,620 | 729 | -- | -- | 39,272 | 16,794 |
| Switzerland | 83 | 25 | 163 | 68 | 90,113 | 36,172 | 158,453 | 63,890 | 228,812 | 100,155 |
| Taiwan | -- | -- | -- | -- | 228 | 88 | 1,181,877 | 561,976 | 1,182,105 | 562,064 |
| United Kingdom | 30,556 | 13,768 | 175,860 | 74,944 | 7,327 | 3,331 | 24,790 | 11,193 | 238,573 | 103,237 |
| Other | -- | -- | 2,927 | 1,197 | 3,504 | 1,273 | 12,781 | 5,457 | 19,212 | 7,929 |
| Total[4] | 44,525 | 19,818 | 903,182 | 390,832 | 610,087 | 264,006 | 2,288,494 | 1,034,186 | 3,846,196 | 1,708,844 |

[r]Revised.
[1]Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Excludes monetary gold.
[2]Includes gold content of base metal ores, concentrates, and matte destined for refining.
[3]Data may not add to totals shown because of independent roundings.

Source: Bureau of the Census.

## Table 15.—U.S. imports for consumption of gold, by country[1]

| Year and country | Ore and concentrates[2] | | Waste and scrap | | Doré and precipitates | | Refined bullion | | Total[3] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity (troy ounces) | Value (thousands) | Quantity (troy ounces) | Value (thousands) | Quantity (troy ounces) | Value (thousands) | Quantity (troy ounces) | Value (thousands) | Quantity (troy ounces) | Value (thousands) |
| 1983 | 239,146 | $94,919 | 146,164 | $51,516 | 606,458 | $256,113 | 3,690,189 | $1,575,570 | 4,592,956 | $1,977,118 |
| 1984 | 202,797 | 69,061 | 357,119 | 122,483 | 1,277,146 | 461,763 | 6,031,550 | 2,295,698 | 7,868,612 | 2,948,914 |
| 1985 | 37,067 | 11,628 | 366,887 | 107,147 | 1,461,068 | 468,227 | 6,380,977 | 2,109,475 | 8,225,999 | 2,696,478 |
| 1986 | 37,618 | 13,094 | 520,317 | 159,786 | 1,391,061 | 504,457 | 13,890,451 | 5,016,533 | 15,749,447 | 5,693,896 |
| 1987: | | | | | | | | | | |
| Australia | 51 | 22 | -- | -- | 35 | 11 | 14,460 | 6,358 | 14,546 | 6,391 |
| Bolivia | -- | -- | 183,537 | 71,163 | -- | -- | 1,685 | 413 | 184,622 | 71,576 |
| Brazil | -- | -- | 257 | 74 | 3 | 1 | 5,012 | 2,187 | 5,272 | 2,262 |
| Canada | 3,622 | 1,499 | 84,875 | 26,819 | 649,072 | 284,842 | 1,235,308 | 554,246 | 1,972,877 | 867,405 |
| Costa Rica | -- | -- | 18,655 | 7,648 | -- | -- | -- | -- | 18,656 | 7,648 |
| Chile | 72 | 31 | 3,465 | 1,592 | 6,077 | 3,195 | 250,009 | 109,513 | 259,623 | 114,331 |
| Colombia | -- | -- | 4,935 | 1,904 | 13 | 7 | 23 | 8 | 4,971 | 1,919 |
| Dominican Republic | 5 | 2 | 37,778 | 9,665 | 235,231 | 99,515 | 23,750 | 9,501 | 296,864 | 118,683 |
| Ecuador | -- | -- | 9,807 | 3,193 | 9,208 | 567 | 874 | 347 | 12,889 | 4,107 |
| Finland | -- | -- | -- | -- | -- | -- | 11,881 | 2,904 | 11,881 | 2,904 |
| Germany, Federal Republic of | 138 | 48 | 338 | 45 | 4,380 | 1,999 | 5,737 | 2,372 | 10,693 | 4,465 |
| Guyana | 8,784 | 3,512 | 3,260 | 1,292 | 223 | 96 | 8,234 | 2,631 | 20,501 | 7,521 |
| Honduras | 2,179 | 716 | 2,418 | 968 | 7 | 3 | -- | -- | 4,604 | 1,707 |
| Ivory Coast | 1,423 | 572 | -- | -- | 441 | 182 | 2,580 | 1,209 | 4,854 | 2,144 |
| Japan | 2,859 | 1,695 | 270 | 62 | 984 | 163 | 964 | 384 | 6,077 | 2,303 |
| Mexico | 11,109 | 4,206 | 11,749 | 3,946 | 330 | 85 | 20,042 | 8,787 | 43,230 | 16,428 |
| Panama | -- | -- | 5,866 | 2,363 | -- | -- | 2,107 | 974 | 7,973 | 3,336 |
| Switzerland | 122 | 48 | 8,593 | 3,758 | 129 | 70 | 50,835 | 23,572 | 59,679 | 27,444 |
| Togo | 12,799 | 5,003 | -- | -- | -- | -- | 396 | 167 | 13,197 | 5,171 |
| United Kingdom | -- | -- | 297 | 129 | 21,798 | 9,482 | 408,279 | 160,781 | 435,374 | 170,392 |
| Uruguay | -- | -- | 5,874 | 2,740 | -- | -- | 319,393 | 137,305 | 325,177 | 140,045 |
| Venezuela | -- | -- | 52,926 | 18,062 | 393 | 167 | 1,167 | 406 | 54,486 | 18,634 |
| Yugoslavia | -- | -- | -- | -- | 3,230 | 1,306 | 56,857 | 24,900 | 60,087 | 26,206 |
| Other | 1,758 | 570 | 13,767 | 5,244 | 958 | 334 | 8,698 | 3,795 | 25,171 | 9,944 |
| Total[3] | 45,931 | 17,926 | 448,667 | 160,073 | 925,612 | 402,026 | 2,423,053 | 1,052,941 | 3,843,253 | 1,632,966 |

[1]Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Excludes monetary gold.
[2]Includes gold content of base metal ores, concentrates, and matte imported for refining.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

## WORLD REVIEW

World demand for gold, including scrap gold for use in fabricated products, declined by 5%, reflecting in part the absence from the market of the Japanese Hirohito coin program of 1986.

According to Consolidated Gold Field's 22d annual review and summary,[11] the total supply of gold to the world's market economy countries remained steady at 64.6 million ounces. Increased mine production in the market economy countries was more than offset by lower sales from the centrally planned economy countries, principally the U.S.S.R., at 9.7 million ounces in 1987 compared with 12.9 million in 1986. Net purchases from the market by the official sector's central banks totaled about 2.2 million ounces, down from 4.6 million ounces in 1986. Karat jewelry manufacture absorbed about 36.6 million ounces, up from about 35.5 million ounces in 1986. Gold used in the minting of official coins fell from the record-high level of about 10.2 million ounces minted in 1986 to about 6.6 million ounces in 1987. The total gold used in industrial applications, including electronics, dentistry, and other uses, remained nearly unchanged at 7.8 million ounces. Identified hoarding of gold bars for investment or asset-fixing, outside of Europe and North America, increased by 25% from nearly 7.1 million ounces in 1986 to over 8.8 million ounces. Generally the volume of gold trading on the major futures and options exchanges around the world rose substantially. Finally, the supply of new gold and gold contained in scrap, exceeded the demand for use in fabricated products by 4.6 million ounces compared with a surplus of about 4.1 million ounces during 1986. However, the firmness of the price throughout 1987 suggests that this surplus of supply over identifiable demand was easily absorbed by investors in Europe and North America.

In April, the South Korean Government began minting gold and silver coins to commemorate the 1988 Olympics to be held in Seoul. Four series of six coins each were to be produced.

In October, the Royal Mint of the United Kingdom announced the issue of its new Britannia gold coin, thereby entering the competitive world gold bullion coin market, currently dominated by the recently issued American Eagle and the Canadian Maple Leaf, as well as by several other gold bullion coins. The new legal tender Britannia, 91.66%-pure gold, was being struck in four weights ranging from 1.0 ounce down to 0.10 ounce.

The year also witnessed the formation of the World Gold Council, an organization funded by world gold producers to promote investment in gold and to encourage gold jewelry sales.

A comprehensive review of gold's monetary and industrial roles and an analysis of the world gold mining industry with an outlook for production to the year 2000 was published in 1987.[12]

**Australia.**—Australia's gold production rose for the seventh successive year. In 1987, 26 new gold mines were commissioned with planned capacity ranging from less than 3,000 ounces per year at many small placer mines to large, mostly open pit, lode mines capable of producing up to nearly 300,000 ounces per year. The State of Western Australia was again the country's largest gold producer. As a consequence of continuing expansion in gold exploration activity, Australia's minable gold resources reportedly increased nearly 25% over 1986 levels. Australia's Bureau of Mineral Resources, Geology, and Geophysics forecast that production would reach nearly 4.2 million ounces in 1988, peak at nearly 4.5 million ounces by 1991, and decline to about 3.9 million ounces by 1992. An increase in the capacity of the country's domestic precious metals refining industry was expected.

Global sales of the new Standard (nonproof) Australian Gold Nugget coin series began in April. Goldcorp Australia, the Government's sales corporation, reportedly initiated sales through distributors in seven countries. The 99%-pure coins, Australia's first bullion coins minted as legal tender, range in weight from 0.10 to 1.0 ounce. During the first 2 months of trading, nearly 250,000 ounces of coins were sold—nearly twice the original sales target of 130,000 ounces. Goldcorp reportedly sold over 350,000 ounces during the year. Its original 3-year global sales target reportedly was about 400,000 ounces.

At the new open pit Kidston Mine, Queensland's largest and Australia's second largest gold mine, opened in 1985, Placer Pacific Ltd. reported recovering nearly

230,000 ounces at a cash cost of $142 per ounce. Placer continued exploration at its Mount Rawdon gold property in Queensland, a potential open pit operation, and at prospects in the Cooper Range area of the State. BMG of Houston, TX, dedicated its new 60,000-ounce-per-year open pit gold mine, which was south of Charters Towers in northern Queensland. The new mine, known as the Pajingo Mine, also was expected to produce about 200,000 ounces of silver per year. Cash production costs over the life of the mine were expected to average $141 per equivalent gold ounce (with byproduct silver converted to equivalent ounces of gold). In April, Pan Australian Mining Ltd. officially opened its new Mount Leyshon gold mine also near Charters Towers. The new open pit heap-leaching operation began leaching in late 1986. It was designed to produce about 45,000 ounces per year during its first 3 years of operation.

Sedimentary Holdings Ltd. and its partners poured their first gold at the Cracow Mining Venture in March. The new mine was expected to produce about 40,000 ounces during the 1987 financial year. Additions to the mill, commissioned in midyear, were expected to raise the milling capacity by nearly 80% to about 250,000 tons per year. Sixty miles south of Townsville, Carpentaria Gold Pty. Ltd., a subsidiary of MIM Holdings Ltd., poured its first gold in December at its new Ravenswood Mine. The new open pit and heap-leaching operation was expected to produce at a rate of about 15,000 ounces per year. In November, Central Coast Exploration NL began mining its Croyden deposit in the Croyden Goldfield of northern Queensland. Annual production was expected to be about 37,000 ounces per year. In southeastern Queensland, Astrik Resources NL started mining at its open pit Agricola deposit. The new mine, using carbon-in-pulp recovery, was expected to yield about 30,000 ounces per year.

Some other Queensland properties moving toward production in 1988 included the 100,000-ounce-per-year Selwyn (Starra) Mine owned by Cyprus Minerals Australia Co. and its partners; Diversified Mineral Resources Ltd. NL's 30,000-ounce-per-year Clocurry property; and Australian Consolidated Minerals Ltd.'s Wirralee Mine in northern Queensland, due on-stream at the rate of 50,000 ounces per year by mid-1983.

Preliminary mining was begun near year-end at the Sheahan-Grants Mine, 20 miles south of Orange in the State of New South Wales, by Cyprus and its partner Climax Mining Ltd. Metal production began in January and should amount to nearly 30,000 ounces per year during the expected 4-year life of the mine. Paragon Resources NL's wholly owned Temora Mine at Wagga Wagga was commissioned in May to begin production at an annual rate of 35,000 ounces. At BHP Gold Mines Ltd.'s wholly owned Brown's Creek open pit property at Blaney, the existing treatment plant was undergoing modification to raise the annual production rate to about 20,000 ounces. Plans called for increasing later production to about 27,000 ounces per year.

In the State of Victoria, the Sandhurst Gold Joint Venture completed a pilot plant run to test a new gold recovery process. The new coal-oil agglomeration process, developed and patented by one of the partners, BP Australia Gold Pty. Ltd., uses a noncyanide technology that is reportedly economical and harmless to the environment. Bendigo Gold Associates Pty. Ltd., Victoria's second largest gold producer, also was recovering gold from Bendigo-area tailings dumps. Also at Bendigo, Western Mining Corp. Holdings Ltd. (WMCH) began preparation for further underground exploration and bulk sampling at the Old Williams United shaft, and Bendigo Mining NL began dewatering at the old Deborah Mine prior to beginning underground exploration. Near Heathcote in central Victoria, Australian Gold Development NL reportedly was planning to rehabilitate the Costerfield gold mine and had begun rehabilitation and dewatering at the old Brunswick Mine.

In Tasmania, Aberfoyle Ltd. and its partners started mining at their Hellyer polymetallic deposit, made viable primarily by its gold content. In eastern Tasmania, Australian Consolidated and its partner Allstate Exploration NL reportedly began clearing the shaft and dewatering the old Beaconsfield gold mine.

In South Australia, the Olympic Dam project at Roxby Downs moved toward a mid-1988 startup. The owners of the huge copper-uranium-gold project, WMCH and BP Australia Ltd., expect to recover more than 90,000 ounces of gold per year in addition to considerable values of copper and uranium.

In July, Dominion Mining Ltd. officially opened its new Cosmo Howley gold mine in the Darwin region of the Northern Territory. Mining at the 40,000-ounce-per-year open pit heap-leaching operation had begun

in late 1986, and the first gold was poured in January. In the south Alligator River area, BHP Gold and its partners, Noranda Australia Ltd. and NBHC Ltd., continued exploration at the Coronation Hill property, where high-grade gold discoveries also reportedly contained associated platinum and palladium values. Cyprus continued development of its Moline Mine, due to begin production in late 1988 at a rate of about 12,000 ounces per year. Producing at a rate of over 60,000 ounces per year, the Granites Mine of North Flinders Mines Ltd. became the Territories' largest producer during the year.

In Western Australia in response to increasing output of Australian gold mines, the State government's Perth Mint announced that it would expand its gold-refining capacity by building two new refineries: One in Perth with a planned capacity of about 3.5 million ounces per year and one at Kalgoorlie capable of refining nearly 1.0 million ounces per year. Both refineries were to replace the existing Perth facility, which has an annual capacity of about 240,000 ounces. Australia's largest gold-producing mine, the Telfer open pit east of Nullagine, commissioned its mill expansion project designed to provide flotation facilities for the treatment of gold-copper sulfide ores. The mine was owned by Newmont Australia Ltd. (70%) and BHP Gold (30%). To the south, between Kalgoorie and Boulder, Newmont began metal production in December at its jointly held New Celebration Mine. Mining begun the previous year was from three open pits, where 500,000 tons of ore per year are now selectively mined and carefully blended to achieve maximum recovery at an expected annual rate of about 40,000 ounces of gold per year. The New Celebration mill was being expanded to handle 1.5 million tons of ore per year.

In December, Gold Mines of Kalgoorlie Ltd. (GMK), announced a proposal, subject to regulatory approval, to acquire all of Kalgoorlie Lake View Pty. Ltd.'s holdings in the Golden Mile area of Kalgoorlie. This acquisition would result in the consolidation of most of the gold mining operations at Kalgoorlie. Control of the Kalgoorlie mines under a single ownership would reportedly result in the formation of the largest gold mining operation in the world outside of the Republic of South Africa.

During its financial year ending in June, Western Mining Corp. and its affiliates' gold mines produced nearly 564,623 ounces, compared with 556,000 ounces during the comparable 1986 period. The Western Mining Group, the dominant gold producer, conducts gold mining operations in the area around Norseman, Kambalda, Kalgoorlie-Boulder, and to the north near Agnew.

Production began in July at an initial rate of 225,000 ounces per year at the Boddington Mine, 70 miles southeast of Perth. Boddington is a joint venture managed by Worsley Alumina Pty. Ltd. on behalf of Reynolds Australia Alumina Ltd. (40%), the Shell Co. of Australia Ltd. (30%), BHP Minerals Ltd. (20%), and Kobe Alumina Associates (Australia) Ltd. (10%). The gold at Boddington occurs in an unusual association with bauxite. Following up on the characteristics of this unusual occurrence, Alcoa of Australia discovered gold in a similar geological environment on its bauxite leases near the Boddington Mine. Reportedly it planned to begin recovering gold in 1988.

Other Western Australia gold mines reportedly beginning production during 1987 included Julia Mines NL's Goongarrie Mine at about 12,000 ounces per year. Nord Resources (Pacific) Pty. Ltd.'s 38,000-ounce-per-year Kurara Mine, formerly known as Reedy's North, began in June. Aberfoyle Exploration Pty. Ltd.'s Bardoc property, expected to produce 38,000 ounces per year, began production in January. The Gabanintha Mine near Meekatharra began production in October at an expected initial rate of about 25,000 ounces per year. Gabanintha was owned by Dominion Mining Ltd., Black Swan Gold Mines Ltd., and Southern Ventures NL. Near Leonora, Hunter Resources and its partners commissioned their 40,000-ounce-per-year Mertondale Mine in February. East Murchison Mining Pty. Ltd. and partners reopened the Gidgee deposit in July. Eastmet Ltd.'s open pit Youanmi Mine poured its first gold in January and was expected to produce at a rate of about 35,000 ounces per year when fully operational.

Kalgoorlie Resources NL commissioned its Premier Mine in August. Queec Margaret Gold Mines NL and Spargo Exploration commissioned their Bellevue Mine in October. Production was expected to reach about 55,000 ounces per year when fully operational. The Mount Fisher Mine, 60 miles east of Wiluna, also began production in October. The owners, Sundowner Minerals NL, expect to produce about 35,000

ounces per year. Freeport-McMoRan Australia Ltd. continued construction on its open pit Karonie project 65 miles east of Kalgoorlie, where initial gold production began in November.

Brazil.—To encourage Brazil's mining industry, the Government of Brazil reportedly adopted a number of fiscal and financial incentives including low-interest loans for equipment and a 10-year corporate tax holiday for projects in the Amazon Basin. To discourage smuggling of gold to other countries, the Brazilian Central Bank reportedly continued its practice of paying a premium for gold. Smuggling, however, remained a problem as production from numerous unregulated, independent miners or "garimpeiros" continued to elude detection as it moved to markets outside of the country.

In the State of Minas Gerais, gold production was begun at yearend at General Mining Union Corp. Ltd.'s (Gencor) 58,000-ounce-per-year underground São Bento Mine. At Nova Lima, in Minas Gerais, Mineração Morro Velho S.A. (MMV), a 70%-owned subsidiary of Anglo-American Corp., operated Brazil's largest gold mine, the Morro Velho Mine, a deep underground operation dating back to the early 1800's. MMV's annual production from its mines in the State of Minas Gerais, the Morro Velho and the Raposos-Cuiaba, and its Jacobina Mine in the State of Bahia was reportedly about 354,000 ounces. Near Paracatu, Rio Paracatu Mineração S.A. poured the first bar of gold at its new 100,000-ounce-per-year Morro do Ouro Mine. The company is a joint venture between Rio Tinto Zinc do Brazil and Autram Mineração e Participações S.A., a consortium of U.S. and Canadian companies.

In the State of Goiás, MMV and its partner Inco Gold Co. continued with the development of their 120,000-ounce-per-year Crixas property, scheduled for production in late 1989. BP Mineração and its partners began production at a rate of about 60,000 ounces per year at the Cabaçal Mine in the State of Mato Grosso. At the Fazenda Brasileiro gold mine in the State of Bahia, Brazil's first open pit and heap-leaching mine, the Cia. Vale do Rio Doce (CVRD) continued development of its underground mine and associated milling facilities. A mid-1988 startup was planned. Another CVRD project in Bahia, the open pit Antas Mine, reportedly moved toward a 1989 startup.

Garimpeiros continued to pursue surface and placer deposits mainly in the States of Amazonas, Mato Grosso, and Pará. In the latter State, garimpeiros continued to work the large gold deposit at Serra Pelada. However, production from this huge hand-dug pit continued to decline as physical factors and a lack of planning further limited the amount of ore available to the miners' primitive methods.

Canada.—The intense gold exploration activity that began several years ago continued in 1987. Much of the heightened activity, especially by junior exploration firms, has been attributed to the Flow-Through Share Program, instituted by the Government in 1983. It enabled companies to issue shares for specific projects and pass the allowable exploration expenses on the project through to the investor, who can in turn deduct the expenses from taxable income earned from other sources. A survey of junior mining companies conducted by the Prospectors and Developers Association reportedly demonstrated that 75% of those firms participating in the survey had used the flow-through program. In June 1987, in an effort to slow down the rapid growth of the program, the Government, as part of the sweeping changes made to the Canadian tax system, introduced changes that affected the Canadian mining industry. Included in the tax reforms scheduled to take effect with the 1988 tax year were changes in the mechanism governing the flow-through program as well as modifications to other tax benefits previously enjoyed by the industry. For example, the earned depletion allowance will be gradually phased out and disappear entirely on July 1, 1989, and the tax writeoff allowable for flow-through share investments will decline from the current level of 133% on selected exploration costs to 100% during the same period.

With the exception of Prince Edward Island, there was at least one gold mine operation in every Canadian Province. Five Provinces lacked gold operations in 1986. Details of developments in Canadian gold mining were summarized in a report prepared by the Canadian Department of Energy, Mines, and Resources.[13]

The amalgamation of several large Canadian gold mining companies during 1987 resulted in the formation of Placer Dome, the largest gold mining company outside of the Republic of South Africa. The companies involved were Placer Development Ltd., Dome Mines Ltd., and Campbell Red Lake Mines Ltd. Formation of another large

company, Hemlo, resulted from the merger of Noranda Inc., Hemlo Inc., Goliath Gold Mines Ltd., and Golden Sceptre Resources Ltd. Inco Ltd., primarily a nickel producer, spunoff its gold assets into a new company concerned solely with gold, Inco Gold.

With 1987 production at about 1,740,000 ounces, Ontario was again Canada's largest gold-producing Province. Increased production at some mines reflected better ore grades and improved recovery. Several new mines began production during the year, including the Golden Rose of Emerald Lake Resources Inc. at Sturgeon Falls and the Bell Creek Mine of Canamax Resources Inc. at Timmons. The estimated annual production expected from these new mines was about 39,000 ounces and 26,000 ounces, respectively. Placer Dome and Amoco Canada Petroleum Co. Ltd. switched from open pit mining to underground at their Detour Lake property, and production in 1988 was expected to exceed 96,000 ounces. At about $96 per ounce, the Golden Giant's production costs were reportedly the lowest in Canada in 1987. The legal dispute that arose during 1986 between Lac Minerals Ltd., owners of the Page-Williams Mine, and International Corona Resources Ltd., joint partners in the David Bell Mine, continued during 1987. In 1986 an Ontario Supreme Court ruled in favor of International Corona, but in late 1987, the Supreme Court of Canada granted Lac Minerals the right to appeal the lower court decision, which had awarded the Page-Williams Mine to International Corona.

Gold mines under development in Ontario during the year included Cameron Lake, Dupont (Shoal Lake), Dona Lake, Golden Patricia, Michikinau Lake, Kremzar, Davidson Tisdale, Diepdaume, Clavos Project, St. Andrews, and Holt-McDermitt. Lac Minerals' Lake Shore gold mine reportedly was closed owing to exhaustion of its ore body.

The Province of Quebec produced 940,000 ounces of gold in 1987, a slight increase over 1986 production. The increased exploration and development activity of 1986 in the Cass Berardi area of northwestern Quebec continued during 1987. The Golden Pond property, a joint venture between Inco Gold and Golden Knight Resources Inc., continued under development toward its scheduled opening in August 1988. The Golden Pond East deposit, scheduled to produce about 60,000 ounces per year, was to be the first of three ore bodies to be developed. Eighteen miles to the east, evaluation continued on the Estrades deposit of Teck Corp. and Golden Hope Resources Inc. In the Rouyn-Val d'Or area, the Province's principal gold-producing area with nine operating mines, Lac Minerals announced a $45 million development plan for its Bousquet No. 2 Mine deposit discovered in 1986. The mine was expected to start at 1,000 tons of ore per day and go to full commercial production at the rate of 2,000 tons per day by 1990, producing 140,000 ounces of gold per year. Agnico-Eagle Mines Ltd. was expected to have its Dumagami Mine and mill, which lies beside Bosquet No. 2, operating by June 1988, producing at a rate of about 64,000 ounces per year. Construction of the Sleeping Giant Mine of Perron Gold Mines Ltd. was completed. The mine was due to begin producing in early 1988 at a rate of about 61,000 ounces per year. An affiliated company, D'Or Val Mines, began production at its Beacon Mine in early 1987.

During the year, the Murray Brook property in New Brunswick and the Tangiers and Cochrane Hills properties in Nova Scotia reached the development stage. In August, Hope Brook Gold Inc., a subsidiary of BP Resources Canada Ltd., began heap leaching at its Hope Brook gold mine on the southwest coast of Newfoundland. The first 17-month mining phase will treat ore mined from an open pit for a recovery of about 17,000 ounces. Phase 2 calls for construction of a 3,000-ton-per-day plant and underground mine to be completed in late 1988. Mining during phase 2 will produce 126,000 ounces per year.

In Nova Scotia, Seabright Resources Inc. modified the old Gays River lead and zinc mill to treat gold ore from its nearby Forest Hill Mine, due to begin operating in 1988. Seabright's nearby Beaver Dam deposit was being developed underground, although two other deposits, the Caribou and Moose River, were less advanced. In the Province of New Brunswick at the Cape Spencer Mine, Gordex Minerals Ltd. planned to convert its heap-leaching recovery system to vat leaching to permit gold recovery year-round. Gordex estimated 1987 production to be about 7,500 ounces.

Granger Exploration Ltd. and the Abermin Corp. began production in May at their Tartan Lake Mine near Flin Flon, Manitoba. Production during 1987 was expected to be 40,000 to 45,000 ounces, rising to 100,000 ounces in 1988. Also in Manitoba, Pioneer expected to begin production at its New Puffy Lake Mine at an annual rate of about

40,000 ounces.

Gold production resumed in the Province of Saskatchewan following a 50-year hiatus. The Star Lake Mine owned by Saskatchewan Mining and Development Corp., Uranerts Exploration and Mining Ltd., and Starrex Mining Corp. began production in early 1987. Several other properties reportedly were also under investigation in the La Ronge region of the Province.

In the Yukon Territory, Canamax Resources and Pacific Trans-Ocean Resources Ltd. began construction at their Ketza River project due to start up in 1988. Borealis Exploration Ltd. reportedly poured its first gold at its underground Fat Lake deposit in the Keewatin District of the Northwest Territories in October. Also in the Northwest Territories, the old Ptarmagan Mine reportedly was nearing an early 1988 start-up under new ownership by Treminco Resources Ltd. Also in the Northwest Territories, Getty Resources Ltd. and Noranda Exploration reportedly were developing their Courageous Lake property.

With 38,000 ounces, the Province of British Columbia was Canada's third largest gold producer, with production from three mines: the Cassiar, Blackdome, and Nickel Plate. The open pit Nickel Plate Mine at Hedley, owned by Mascot Gold Mines Ltd., was reopened in midyear and was expected to produce nearly 120,000 ounces per year. Properties under development during the year included the Cinola, Golden Bear, Lawyers, and Reg.

**Caribbean Basin.**—Because of worldwide interest in exploring high-tonnage, low-grade epithermal gold deposits along crustal plate boundaries, several companies began to focus their attention on the Caribbean crustal plate. The theoretical boundaries of this plate extend from mid-Guatemala south to Panama, east through Guyana, north along the east side of the Lesser Antilles, then westward between Haiti and Cuba, and back to Guatemala. Many geological and mineralogical characteristics associated with the recent significant gold discoveries around the Pacific Rim and in particular in Papua New Guinea have been recognized at some gold deposits around the Caribbean Plate. Countries in the region where gold has been produced include the Dominican Republic, where Rosario Dominicana S.A. has been mining gold at its Pueblo Viejo gold mine for many years. Pueblo Viejo is the largest open pit primary gold mine in the Western Hemisphere. Other producers include Costa Rica, Guyana, Honduras, and Nicaragua, where numerous small mines were producing gold in 1987. They also include El Salvador, Panama, and Puerto Rico, where gold has been produced for years on an intermittent basis.

In addition to the ongoing United Nations Department of Technical Cooperation's exploration work at several gold deposits in Haiti, companies known to be exploring for gold in the Caribbean include Canyon Resources Corp., Antilles Resources Ltd., Cyprus Gold Co., Homestake, Chevron Resources, and Freeport Minerals Co. These companies and others from Australia, Japan, and Panama reportedly have been especially attracted to the Dominican Republic following a 1987 decree that opened heretofore unexplored areas of the island previously ruled to be off limits to commercial development.

The Nicaraguan Ministry of Mines reported that the La India Mine, 25 miles northeast of León, was scheduled for rehabilitation through a joint U.S.S.R.-Nicaragua effort. At one time, the mine produced about 30,000 ounces of gold and 40,000 ounces of silver per year. Several other mines, including the La Liberdad, Siuna, and the El Limón Mines were reported to have been producing gold in 1987. Several others reportedly were being reactivated. Despite efforts by the Government to encourage increased production, widespread smuggling of gold to other countries occurred in response to the Government's policy of paying only $50 per ounce for domestic gold. Reportedly, this smuggling resulted in a loss of up to 75% of the estimated total production. Attacks by anti-Government forces on mining towns reportedly have also interrupted production.

**Ecuador.**—The large changes to earlier published estimates of Ecuadorean gold production shown in table 16 reflect recent data reported by the Government of Ecuador. Minera Nambija, a joint Government- and cooperative-owned gold mining company, reportedly was considering applications from nine companies to operate a new automated plant at the Nambija Mine in southern Ecuador. In addition to Nambija, the country's major lode gold mining areas include Portovelo, Ponce Enriquez, and Zaruma. Other areas known to be rich in gold include Paccha and Piñas. Many of Ecuador's river systems reportedly contain rich deposits of placer gold.

Government mining officials in Ecuador

were predicting that large increases in future gold production would accrue from ongoing Government efforts to encourage more domestic mining. This activity would reportedly help to offset foreign exchange losses incurred as a result of declining world oil prices. New mining laws decreed in 1986 and 1988 set forth a number of incentives for foreign investment, including various tax breaks and exemptions from import duties, streamlined permitting and speedier resolution of judicial disputes, and reduced royalty and prospecting fees.

Europe.—Limassol S.A. of Greece reportedly began experimental mining of a gold property on the island of Cyprus. The Hellenic Industrial & Mining Investment Co. of Greece contracted for a basic engineering study aimed at recovering gold from an arseniferous pyrite concentrate produced at the Olympias Mine in northern Greece.

In the Huelva Province of southwestern Spain, Thorco Resources Inc. of Toronto, Canada, reportedly was preparing for a 1988 startup of its developing Tharsis gold and silver heap-leaching project. The project will reportedly be the only heap-leaching operation in Europe. Spain's Instituto Nacional de Industria reportedly was also planning to restart a gold mining operation at Rodalguilar in Almeria Province.

Reports of gold exploration and/or work directed toward reopening long-closed gold mines came from the Federal Republic of Germany and Yugoslavia.

On March 12, Belgium became the first European Economic Community (EEC) country to mint European Currency Unit (ECU) coins as legal tender. The gold and silver coins were minted to mark the 30th anniversary of the Treaty of Rome. The ECU, an artificial currency created in 1979, is based on the combined value of 10 of the 12 EEC currencies. The number of coins to be minted under the program has not been decided. Near yearend more than 500,000 gold ECU's reportedly had been sold.

The U.S.S.R. was estimated to be the world's second largest gold producer, behind the Republic of South Africa. However, since 1933, gold production data have been a state secret.

At least one new Soviet gold mine, the new open pit Kirgiz gold mining complex in Kirgizia in southern Russia reportedly was scheduled for completion during the 1986-90 5-year planning period.

Ireland and Scotland.—Ennex International PLC reported that permission was received to proceed with its plan to go underground at its Curraghinalt property in County Tyrone, Northern Ireland. If the results of this work are positive, Ennex will seek approval to commission a mining operation at a rate of about 30,000 ounces per year starting in 1989. Ennex also reported that exploration nearby, as well as in the Dooros area of Connemara, had uncovered gold mineralization. The company was also exploring and planning the development of a gold-silver prospect at Cononish, Scotland, reportedly the first substantial discovery of gold or silver in that country.

Ennex's success in Ireland has stimulated a number of other companies to explore there for gold. Nearly 800 mineral exploration licenses reportedly were either in effect, approved, or pending approval by Government authorities.

Oceania.—Indonesia lies in an area believed to be influenced geologically by the convergence of four major crustal plates: the Eurasian, Indo-Australian, Pacific, and Philippine Plates. In recent years, discoveries of epithermal gold deposits have been largely along the southern rim of the Pacific Plate from Indonesia east and south to New Zealand. Exploration companies, recognizing the potential for further discoveries in Indonesia, have intensified their work in that country. According to news media reports released near yearend, foreign firms intent on gold exploration had signed 32 contracts with the Government during the first 10 months of 1987 and a further 28 were expected before yearend. About 600 companies reportedly were waiting for their contract applications to be processed. Most of the companies so far have been Australian. However, a growing number was from nations in the Northern Hemisphere. As was the case earlier in Brazil and later in the Philippines, the growing wave of officially sanctioned exploration has increasingly brought the mining companies into potential conflict with timbering companies and illegal miners operating in remote areas of the vast island archipelago. A number of mines, including Freeport Indonesia Inc.'s Ertzberg copper-gold-silver mine in West Irian, have been in operation for years. The major areas of active gold mining include the southern Provinces of Kalimantan, Maluku, Sulawesi, Sumatra, West and East Nusa Tenggara, and West Irian.

The mining industry in Papua New Guinea is the single most important element of

the nation's economy. Five new mines, reportedly representing a potential investment of $1.35 billion, will soon begin production in that nation. They are Lihir, Misima, Porgera, Uramit, and Wapulu.

The nation's largest existing gold mine, the giant Ok Tedi Mine in the Star Mountains, reportedly produced nearly 600,000 ounces of gold in 1987. Ownership of the mine, in addition to the Government's 20% stake, was vested in a consortium of international mining companies. With a midyear shipment of copper concentrates to Japan, Ok Tedi officially entered its planned copper-producing phase, during which both gold and copper will be principal products. Papua New Guinea's second largest gold producer was Bougainville Copper Ltd.'s mine on Bougainville Island. Gold production, a byproduct of copper mining, amounted to nearly 500,000 ounces during 1987.

CRA Ltd. of Australia reported that drilling at its Hidden Valley project in the Wau-Bulolo region of Morobe Province of Papua New Guinea had returned promising results. At Wau, New Guinea Goldfields Ltd., controlled by Renison Goldfields Consolidated Ltd., reported producing nearly 21,000 ounces of gold from its Wau mines. The large increase over the previous year's production of 5,700 ounces largely reflected the efficiency of its new mill and carbon-in-pulp plant. Renison reportedly entered into an agreement with City Resources Ltd. to explore the placer gold potential of Renison's holdings in the Bulolo goldfield. Dredging in the area from 1931 to 1967 reportedly did not fully exploit the potential of the field.

In late 1987, Niugini Mining Ltd. announced that production had begun at its 100%-owned Mount Victor Mine near Kainantu in Papua New Guinea's Eastern Highlands Province. Annual gold production from the open pit operation was estimated to be 12,000 to 15,000 ounces. A unique feature of the mine's plant including housing, workshops, and powerplant, was that it is fully self-contained and portable. When mining is completed in 2 or 3 years, the entire plant can be moved intact to the next minesite. Niugini also holds a 25% interest in the recently discovered Lihir gold deposit, one of the largest outside of the Republic of South Africa. Ore reserve data compiled during 1987 indicated a minable reserve in excess of 18 million ounces of gold. The company's partner in the project, situated on Lihir Island east of the island of New Ireland, is Kennecott Explorations (Australia) Ltd. Niugini announced at yearend that a third area of gold mineralization, the Kapit Ore Zone, had been discovered near the two known principal ore bodies. The company was also exploring recent discoveries in the Tabar Islands group northwest of Lihir. Drilling and sampling were proceeding at 12 prospects scattered between the islands of Simberi, Tabar, and Tatu. Other companies, too numerous to mention here, were exploring gold prospects on other Papuan islands including New Britain, Fergusson, Woodlark, and the Tanga and Feni Islands. Toward the southeast, other companies were exploring in Vanuatu, the Solomon Islands, Fiji, and New Zealand.

In the Solomon Islands, the placer mine of Zanex Ltd. and Mavu Gold Development at Mavu on Guadalcanal Island, resumed production after having been closed in late 1986 owing to the destruction of its recovery plant during a typhoon. Annual gold capacity at the site, the Solomon's only large gold mine, was 13,000 ounces. If two nearby deposits prove to be economic, the capacity may be expanded to 50,000 ounces per year. Cyprus Minerals Co.'s Gold Ridge property on Guadalcanal reportedly was in an advanced stage of exploration.

At the Emperor gold mine on the island of Viti Levu in Fiji, the Vatukoula Joint Venture, 80%-owned by Emperor Gold Mining Co. Ltd. and 20% by Western Mining Corp. Holdings (Fiji) Pty. Ltd. produced nearly 102,000 ounces during the fiscal year, compared with 76,797 in the previous year. Production was derived from both open pit and underground sources. Production was begun at the nearby Tavua Basin Joint Venture in which Western Mining holds a 50% interest. During the year, exploration on the island of Vanu Levu by United Resources (Fiji) Ltd., a subsidiary of City Resources, reportedly resulted in the discovery of gold values associated with an identified epithermal system.

New Zealand has been a small gold producer for many years. Combined with the recognition of the epithermal origin of some known deposits, this fact has spurred an interest in more exploration. Some of the companies currently exploring for or developing gold deposits in New Zealand include Homestake, BP Minerals, AMAX Exploration (New Zealand) Inc., Australian Consolidated, and BHP Gold. Some of the properties undergoing examination or develop-

ment on North Island include Karangahke, Golden Cross, Martha Hill, and Waihi. Properties on South Island include Sam Creek, Macraes Flat, and various placer goldfields such as those at Otago.

The search for gold in the South Pacific spilled over in 1987 into heretofore relatively unexplored regions. The rediscovery of gold at Rois Malk in the State of Airai in Palau and the recognition of the epithermal origins of the prospect by the U.S Geological Survey in 1985 apparently served as a catalyst for at least one company to explore the potential there and to expand the scope of its search to other targets in the South Pacific region. Micronesian Mineral Resource Co. Ltd. of Vancouver, Canada, in partnership with Nord Australia conducted a detailed study of the Rois Malk area in 1986. In 1987, the partners reportedly expanded their search toward the east and northeast for other areas where epithermal systems may occur. Their exploration reportedly was conducted in the Caroline Islands group of Micronesia, then in the Northern Mariana Islands. The islands of Kosrae (Kusaie), Ponape, and Yap (Pohnpei), and later the island of Saipan were the principal points of investigation. Work was planned for the islands of Guam and Truk in 1988.

Responding to the widespread interest in gold exploration in the Pacific Rim, the Queensland, Australia, State government, and four major corporate sponsors hosted an international congress in Queensland on the geology, structure, mineralization, and economics of the Pacific Rim. The conference was convened from August 26 to 29 under the auspices of the Australasian Institute of Mining and Metallurgy.

Peru.—In an effort to stimulate greater domestic gold production, the Government of Peru reopened the San Antonio de Poto Goldfield in Puno in the high Andes Mountains of southeastern Peru near the Bolivian border. The remote and isolated area was considered by the Government to be Peru's most important gold mining area. Empresa Minero Perú S.A. (Minero Perú) the Government company that operates several small placer mines in the Ananea section of the goldfield, invited local and foreign companies to participate in financing or in joint ventures with Minero Perú to establish mining in the Ananea area. Nearly 36 international companies reportedly purchased bidding instruction packages.

In early 1987, Peru announced the discovery of important gold placer deposits near the Cordillera del Condor, close to the Ecuadorean border. Gold reserves were estimated at over 3.2 million ounces. Plans for the project, called CHINCORCO, include more exploration and the installation of a small pilot plant. Operations in the region were expected to be complex and to pose difficulties because of the rugged terrain. The announcement aroused a long-standing conflict between Ecuador and Peru because the discovery area lies in territory of disputed national ownership.

Philippines.—The gold rush that began several years earlier on the island of Mindanao continued to mature. Centered around the Gulf of Davao from Compostela eastward to Pantukan and Mount Diwalwal, an estimated 200,000 people were engaged in mining, processing, and refining gold as well as providing services to the largely artisan industry. Most of the processing reportedly was centered around the village of Tagum, where up to 1,600 ounces of gold or more were produced in the area per day.

In the Camarines Norte Province of southern Luzon, Benguet Corp. reportedly began production at its Paracale gold project. Production at the new facility was expected to amount to about 22,000 ounces of gold and 49,000 ounces of silver per year. Benguet also continued to rehabilitate the La Suerte Mine, a former gold producer. Benguet was the largest gold producer in the Philippines, with overall gold production in 1987 amounting to nearly 250,000 ounces. Benguet Exploration Inc.'s King King gold mine in Davao del Norte Province reportedly came into production during the year following the completion of three heap-leaching pads and an associated recovery plant. Construction of an additional recovery plant and nine new pads was also reportedly nearing completion.

Gold production at Atlas Consolidated Mining & Development Corp.'s heap-leaching operation on Masbate Island amounted to about 63,000 ounces in 1987. Five 75,000-square-foot asphalt leaching pads were employed. Gold production from Atlas Consolidated's gold-copper operations on Cebu Island reportedly totaled 78,500 ounces. Development continued on new underground gold mines, the Bin Star and the Dabu-Pinigue, with startup scheduled for early 1988. Two others, the Colorado Mine and IXL Mine, were due to begin underground production later that year.

City Resources (Asia) Ltd. a Hong Kong-based firm, reportedly purchased a controlling interest in Manhattan Mining Corp. of the Philippines for the purpose of exploring leases held by Manhattan.

Paragon of Australia reportedly was exploring claims held by its partner, Philippine Eagle Mines. Paragon's interest was apparently focused on reserves remaining at the old Philippine Eagle Mine at Longos in southern Luzon. Kenmare Resources, based in Dublin, Ireland, reportedly initiated an agreement with the Philippine National Oil Co. to explore for epithermal gold on concessions held by the oil company on southern Luzon and the islands of Leyte and Negros. On the island of Lahuy, 200 miles southeast of Manila, Genoa Resources and Investment Ltd. reportedly was searching for evidence of epithermal systems at the old underground Treasure Island Mine. Finally, Galactic Resources of Vancouver, Canada, reportedly signed a joint-venture agreement with Lepanto Consolidated Mining Co. Inc., to develop a major gold-copper-porphyry discovery at Mankayan in Benguet Province. The deposit, known as the Far South East Porphyry Project, reportedly was thought to contain 12 million ounces of gold and 4.5 billion pounds of copper.

South Africa, Republic of.—Despite continuing labor strikes and unrest, continuing currency inflation, and declining ore grades, the Republic of South Africa remained the world's largest gold-producing nation, with 37% of world mine production in 1987.

Of the 19.2 million ounces of gold produced in the Republic of South Africa during the year, 18.4 million ounces was produced by the 30 mines that together represent the membership of the Chamber of Mines of South Africa. The remainder was recovered by small independent gold producers or as a byproduct of other mining sectors. Overall, 46 gold mines and 16 retreatment plants were producing gold in 1987. The total ore milled by Chamber members, including ore milled by producers of byproduct and coproduct uranium, amounted to 118.6 million tons, averaging 0.17 ounce of gold per ton. In 1986, 118.7 million tons, averaging 0.18 ounce per ton was milled. Working costs for South African gold mines in 1987 averaged $276.05 per ounce and ranged from $139.69 per ounce at the Kloof Mine to $585.30 per ounce at East Rand Proprietary.[14] Production by the six major mining groups was as follows, in millions of ounces: Anglo American Corp. of South Africa Ltd. (AAC), 7.1; Gold Fields of South Africa Ltd., 4.1; Gencor, 2.9; Rand Mines Ltd., 1.8; Anglovaal Ltd. (AVL) 1.3; and Johannesburg Consolidated Investment Co. Ltd. (JCI), 1.2.

In terms of individual mine output, the largest South African gold mines, in millions of ounces of production, were AAC's new Freegold Mine with 3.2, Vaal Reefs North and South lease areas with 2.3, Driefontein Consolidated with 2.1, Western Deeps with 1.1, Hartebeestfontein with 1.0, and Kloof with just under 1.0.

The National Union of Mineworkers (NUM) represent primarily black miners and have an estimated paidup membership of 200,000 workers out of a total mine work force of about 800,000. In August, NUM went on strike at operations held by the major mining groups. AAC and Gencor operations witnessed the most strike activity. The primary issue was NUM's negotiation of a 30% increase in basic wages plus certain fringe benefits. Stockpiling of run-of-mine ore prior to the strike and immediate transfer of office personnel to production lines served to lessen the impact of the strike on gold production. The strike ended after 3 weeks.

In late 1987, Gencor announced plans to develop its new Oryx Mine alongside its existing Beisa property south of the town of Welkom in the Orange Free State. The Beisa, a gold and uranium producer, had been closed since 1985. Initial production from the Oryx will begin in mid-1988 and will employ some of the surface and underground facilities of Beisa, while building by 1994 to an annual capacity of about 2.9 million tons of ore per year, containing 480,000 ounces of gold. Following a 10-year research program, Gencor's new bacterial oxidation demonstration plant completed its first full year of operation in October; it is the world's first full-scale integrated gold recovery plant designed and built specifically to incorporate a proprietary biological preleaching circuit. The plant, at the company's Fairview gold mine in the eastern Transvaal was used to pretreat the mine's refractory ores. Owing to the presence of certain mineral constituents, these ores are difficult and expensive to treat using conventional techniques. Gencor claimed that a 95% gold recovery had been achieved with the aid of the new process.

The consistently high gold prices in terms of rands over the past several years has

encouraged the formation of an increasing number of small gold mining establishments. Consequently, plans to construct several small gold mining operations have been announced that are scheduled to begin production before 1990 and be at full capacity by 1995. These include the Osprey and Southgo Mines due in late 1987, the Eersteling and Sub-Nigel Mines due in 1988, and several others including the old Roodepoort underground mine west of Johannesburg that was reopened in August 1987. Owned by Roodepoort Gold Holdings (Pty.) Ltd., the mine was expected to produce about 4.2 million ounces during an anticipated mine life of 14 years. Gold recovery was to be through a new 20,000-ton-per-month carbon-in-pulp plant.

Rand Mines and AAC decided to develop a new gold mine in the Barberton area of the eastern Transvaal. The new mine will be developed by Barbrook Mining and Exploration Co. with each of the two mining groups holding an equal interest. Commissioning was expected during the third quarter of 1989 with full production of about 33,000 ounces per year expected by early 1990.

The Drylands Mine, the nation's first heap-leaching operation to treat only primary gold ore, reportedly was started up during the year. Production was expected to amount to about 64,000 ounces over a 4-year period. In October, East Rand Gold and Uranium Co.'s (Ergo) new Daggafontein recovery plant was commissioned. The new plant, Ergo's third such plant, will process old gold mine tailings for an annual recovery of about 96,000 ounces of gold. It has been estimated that tailings accumulated in the various Witwatersrand goldfields may contain as much as 42 million ounces of gold. Ergo, owned by AAC, is the largest of the companies formed to process gold-bearing tailings. Other such producers include the Joint Metallurgical Scheme, the Rand Mines Milling and Mining Co., on the Central Rand, and Gencor's Chemwes plant, in the Klerksdorp area.

Petchefstroom Gold Areas, an independent mining firm, confirmed the presence of a gold-bearing reef in the Petchefstroom Gap area in the western Transvaal. The reef, known as the Bird Reef, was believed by some geologists to correlate with the extremely rich Vaal Reef. The drill intersection, at a depth of 12,600 feet, indicated grades of 0.5 ounce per ton over a width of nearly 2.5 feet. Two other intersections nearby, however, indicated much lower values. The discovery was considered by some to be the most significant since the establishment of the Evander Field almost 30 years ago. Although the country may be on the brink of establishing a new gold mining area, some less confident observers pointed out that the cost of establishing new gold mines in the area would be extremely high as a result of the depth of the reef and the small width of the gold-bearing seam.

Rhombus Mining and Exploration Co. Ltd., also an independent company, announced that drilling had intersected rocks of the lower Witwatersrand system at a depth of 7,200 feet at a site about 60 miles south of Beatrix in the Orange Free State. The discovery was significant in that some geologists have theorized for years about the possibility of the Witwatersrand Basin extending into the southern Orange Free State. It was believed that additional carefully placed drill holes will intersect the overlying gold-bearing upper Witwatersrand system. In addition to the two areas above, exploration by the major mining groups and an increasing number of independent mining and exploration companies was being concentrated north of Evander on the East Rand, south of the Western Areas gold mine in the Western Transvaal, south of Klerksdorp in the far western Transvaal, the Bothaville Gap area, and south of the Free State Mine in the Orange Free State. Oil rigs capable of drilling to great depth were being used by some firms in their exploration work.

Mining research was conducted by the South African Chamber of Mines and the individual mining groups. New mining methods, including improved mine support systems, more rapid and efficient ore removal systems, improvements in underground safety and working environments, and the greater use of computers to streamline various operational tasks were some of the benefits developed and operational.

Plans were announced by Rand Refinery Ltd. during the year to construct a new gold-refining facility. The existing refinery, where all of South Africa's gold is refined, processes about 50% of the gold produced in the market economy countries. The new refinery was to have an annual input capacity of about 26 million ounces of raw gold, generally containing 84% gold, 11% silver, and 5% base metals. Construction was scheduled to begin in early 1988 and the refinery was expected to be in operation in about 2 years. The new plant was to be at the same site as the existing refinery.

## Table 16.—Gold: World mine production, by country[1]

(Troy ounces)

| Country[2] | 1983 | 1984 | 1985 | 1986[p] | 1987[e] |
|---|---|---|---|---|---|
| Argentina | 24,660 | 22,120 | 28,357 | 30,350 | 30,000 |
| Australia | 983,522 | r,e1,206,963 | e1,881,491 | 2,413,842 | 3,472,000 |
| Bolivia | 49,217 | 40,527 | e30,000 | 24,521 | 20,000 |
| Brazil[e,3] | r1,950,000 | r1,900,000 | r,e2,200,000 | r,e2,200,000 | 2,200,000 |
| Burkina Faso[4] | -- | 500 | 50,000 | 90,019 | 90,000 |
| Burundi | 272 | 1,115 | 929 | 900 | 1,000 |
| Cameroon | 361 | e250 | 215 | 248 | 250 |
| Canada | 2,363,411 | 2,602,786 | 2,815,118 | e3,364,700 | 3,750,000 |
| Central African Republic | 2,492 | 6,963 | 6,023 | e6,000 | 6,000 |
| Chile | r570,964 | r541,084 | 554,278 | 576,719 | 530,000 |
| China[e] | 1,850,000 | 1,900,000 | 1,950,000 | 2,100,000 | 2,300,000 |
| Colombia | r426,517 | r,e730,670 | 1,142,285 | 1,236,423 | e950,711 |
| Congo | 287 | 101 | 515 | r,e500 | 500 |
| Costa Rica[e] | 30,000 | 35,000 | e15,397 | 11,000 | 13,000 |
| Dominican Republic | 354,023 | 328,272 | 328,046 | e242,500 | 246,000 |
| Ecuador | r97,000 | 220,000 | 300,000 | 317,227 | 320,000 |
| El Salvador | 650 | 285 | -- | -- | -- |
| Ethiopia[e] | 14,000 | 15,000 | 15,000 | 15,000 | 15,000 |
| Fiji | 40,124 | 48,515 | 60,707 | 54,502 | 55,000 |
| Finland | 25,206 | 29,067 | 19,120 | 37,690 | 60,000 |
| France | 71,650 | 70,279 | 90,021 | 73,618 | 64,000 |
| French Guiana | 8,938 | 10,127 | 8,005 | 10,481 | 11,000 |
| Gabon | e500 | 1,325 | 1,988 | 2,000 | 2,000 |
| Germany, Federal Republic of[e] | 1,900 | 1,800 | 1,200 | 1,250 | 950 |
| Ghana | 276,000 | 287,000 | 290,263 | 287,127 | e320,000 |
| Guyana | 4,607 | 11,131 | 10,223 | 14,035 | 15,000 |
| Honduras | 2,151 | 2,784 | 5,023 | 2,018 | 2,500 |
| Hungary[e] | 20,000 | 20,000 | 20,000 | 18,000 | 18,000 |
| India[e] | 70,158 | 65,234 | 58,771 | 60,250 | 58,000 |
| Indonesia[e] | 76,550 | 78,677 | 93,698 | 102,942 | 114,500 |
| Japan | 100,921 | 103,519 | 170,525 | 330,515 | e276,432 |
| Kenya | 100 | 600 | 442 | 2,329 | 2,500 |
| Korea, North[e] | 160,000 | 160,000 | 160,000 | 160,000 | 160,000 |
| Korea, Republic of[e] | 72,083 | 79,156 | 77,258 | 149,436 | 150,000 |
| Liberia[e,5] | 15,400 | 10,500 | 4,900 | r,e20,100 | 15,000 |
| Madagascar[e] | 110 | 130 | 130 | 130 | 130 |
| Malaysia | 84,496 | 89,527 | 90,304 | 88,385 | 100,000 |
| Mali | e13,000 | 16,075 | 16,075 | r,e19,500 | 22,500 |
| Mexico | 198,177 | 270,996 | 265,693 | 250,615 | 250,000 |
| Namibia | 7,459 | 6,302 | 6,227 | r,e6,400 | 6,400 |
| New Zealand | 9,667 | 21,005 | 45,011 | e46,000 | 45,000 |
| Nicaragua | 46,428 | 25,316 | 24,497 | 29,664 | e31,625 |
| Papua New Guinea | 579,407 | e835,000 | 1,186,615 | 1,127,686 | e1,069,011 |
| Peru | 168,584 | 197,406 | 212,970 | 215,982 | 215,000 |
| Philippines | 816,536 | 827,149 | 1,062,997 | 1,296,400 | 1,071,300 |
| Portugal | r16,398 | 6,205 | 9,270 | 6,173 | 5,000 |
| Romania[e] | 65,000 | 65,000 | 65,000 | 60,000 | 60,000 |
| Rwanda | 623 | 240 | 238 | 209 | 200 |
| Sierra Leone[10] | 12,000 | r18,223 | 19,004 | 12,000 | 15,000 |
| Solomon Islands | r1,100 | 2,572 | 2,100 | 3,150 | 4,000 |
| South Africa, Republic of | 21,847,310 | 21,860,933 | 21,565,230 | 20,513,665 | e19,227,887 |
| Spain | 162,296 | 123,330 | 185,524 | 167,184 | 148,000 |
| Sudan[e] | 500 | 1,500 | 1,500 | 1,600 | 1,600 |
| Suriname | 492 | 322 | r,e400 | e600 | 700 |
| Sweden | r108,300 | r141,600 | 145,900 | r,e130,000 | 130,000 |
| Taiwan[r] | 52,961 | 37,794 | 31,633 | 29,270 | 27,000 |
| Tanzania | e800 | 2,680 | 1,776 | 2,735 | 3,000 |
| U.S.S.R.[e] | 8,800,000 | 8,650,000 | 8,700,000 | 8,850,000 | 8,850,000 |
| United States | 2,002,528 | 2,084,615 | 2,477,292 | 3,720,015 | e4,966,382 |
| Venezuela | e33,200 | e50,885 | 74,120 | e92,400 | 88,000 |
| Yugoslavia | r136,250 | 125,150 | r,e110,000 | r,e115,000 | 115,000 |
| Zaire | 192,980 | 117,115 | 63,022 | 167,827 | 160,000 |
| Zambia | 10,160 | 12,185 | 7,909 | 1,865 | 1,800 |
| Zimbabwe | 453,373 | r478,907 | 472,327 | 477,535 | 485,000 |
| Total | r45,163,264 | r46,827,464 | 48,148,988 | 51,619,577 | 52,480,781 |

eEstimated. pPreliminary. rRevised.

[1]Table includes data available through June 10, 1988.

[2]Gold is also produced in Bulgaria, Burma, Cuba, Czechoslovakia, the German Democratic Republic, Guinea, Norway, Poland, Senegal, Thailand, and several other countries. However, available data are insufficient to make reliable output estimates.

[3]Excludes gold in bismuth concentrate.

[4]Excludes gold in gold ore and concentrate from South Australia.

[5]Officially reported figures are as follows, in troy ounces: Major mines: 1983—199,206; 1984—213,963; 1985—244,249; 1986—400,646; and 1987—300,000 (estimated). Small mines (garimpos): 1983—1,326,775; 1984—982,625; 1985—709,780; 1986—476,050; and 1987—500,000 (estimated).

[6]Reported figure.

[7]Refinery output.

[8]Excludes production from so-called people's mines, estimated at 482,000 troy ounces per year during 1986 and 1987, but includes gold recovered as byproduct of copper mining.

[9]These figures are based on gold taxed for export and include gold entering Liberia undocumented from Guinea and Sierra Leone.

[10]Data are based on official exports and do not reflect gold moved through undocumented channels.

## TECHNOLOGY

The Bureau published a report to aid the Minerals Management Service in designating specific offshore areas for consideration of near-term lease offerings. Three selected placer areas, one each for chromium, gold, and titanium, were investigated and evaluated using engineering cost models. The gold placer area was offshore Nome, AK. Sensitivity analyses were then performed on major physical and engineering parameters affecting the economic viability of mineral resources from these three locations.[11] The Bureau examined aggregate trends in foreign direct investment in the U.S. mining and mineral industries between 1977 and 1984. It provided an analysis of foreign investment in several major mineral commodity industries including the gold industry. In 1985, the proportion of the U.S. gold mining capacity held by foreign investors amounted to 44%. The motivation behind the growth in foreign investment and an examination of U.S. policies toward this investment and the issues raised were addressed.[12] A method of estimating capital and operating costs associated with the exploration, mining, and processing of placer deposits was published by the Bureau. Operational parameters for placering equipment and basic principles of placer mining techniques were detailed in a manner to ensure representative cost estimates.[13] The Bureau published an inventory of potential mineral supplies in the United States, including gold. Availability curves depicting how much gold can be recovered as a function of the cost of production were prepared. The chapter on gold identified the mines and processing plants evaluated and provided information on the engineering aspects of these operations. Geology and resources, historic production and current capacities, and mining and processing technologies were presented.[14]

The current and future uses of gold in combating cancer, lessening the pain of arthritis, and other current and future applications of gold were presented at the first International Conference of Gold and Silver in Medicine held in Bethesda, MD, May 13-15, 1988. The conference was sponsored by the Gold and the Silver Institutes, both in Washington, DC.[15]

The Governor of South Dakota awarded $71,800 to the South Dakota School of Mines and Technology to study chlorination extraction for processing metallic ores. The process may prove to be an economic alternative to cyanide extraction. The money was part of a recently established employer's Investment in South Dakota's Future Fund, which uses residual funds from the State's Unemployment Insurance Funds. The study was to include acquisition of ore samples from the Black Hills and other western gold-producing localities. The samples then were to be tested for their amenability to the process. Economic feasibility of the concept was to be assessed on selected gold and silver ores, and a commercial reactor for chlorination processing was to be designed.[16]

A new gold alloy, called 990 Gold, composed of 99% gold and 1% titanium, was developed and patented by the World Gold Council's Gold Information Center. The new alloy allows for the manufacture of almost pure gold articles with improved hardness and good wear properties. The alloy is manufactured by melting the constituents in a vacuum or in an argon atmosphere, followed by casting. By heat treatment at about 800° C and 500° C, the alloy can be obtained in its soft and hardened forms, respectively. The 990 Gold reportedly is easy to work in sheet, strip, or wire form but cannot be cast. Handy & Harman (New York) was licensed to manufacture and distribute 990 Gold stock.[17] A cupric chloride process that would retrieve gold from electronic devices, scrap metal, or discarded jewelry was developed by researchers at the University of Wisconsin.[18] A system, which recovers precious metals including gold from scrapped automobile catalytic converters, was being marketed by Mitsui & Co. (USA). The metals are dissolved in hydrochloric acid and then deposited electrolytically onto carbon particles. After redissolving in acid, the pure metals, including gold and silver, are selectively precipitated.[19] Pulse-plated gold deposits for aerospace components were reported superior to those produced using DC electrolytic plating processes. Pulse-plating yielded deposits with higher infrared reflectivity, decreased porosity and thermal emissivity, smoother and brighter surfaces, and greater density.[20]

A collection of papers addressing various aspects of heap-leach pad construction, monitoring and analysis of solution flow through the heap and its collection, and the design of construction pads was published as a reference for the development, design, and operation of heap-leaching projects.[21]

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